DISCOVERY

Monthly Notebook
DAVID S. EVANS M.A., Ph.D., F.Inst.P.

Professor J. B. S. Haldane, F.R.S.
WILLIAM E. DICK

Molecule or Organism?
KENNETH M. SMITH D.Sc., F.R.S.

Science and Athletic Events
G. T. P. TARRANT M.A., Ph.D.

Nature's Camouflage in Britain
REGINALD GAZE F.R.P.S.

The Scope of Microchemistry
DAVID L. MASTERS M.Sc., Ph.D.

Electric Heating in Plywood Manufacture
A. W. ALLWOOD, B.Sc., A.M.I.E.E.

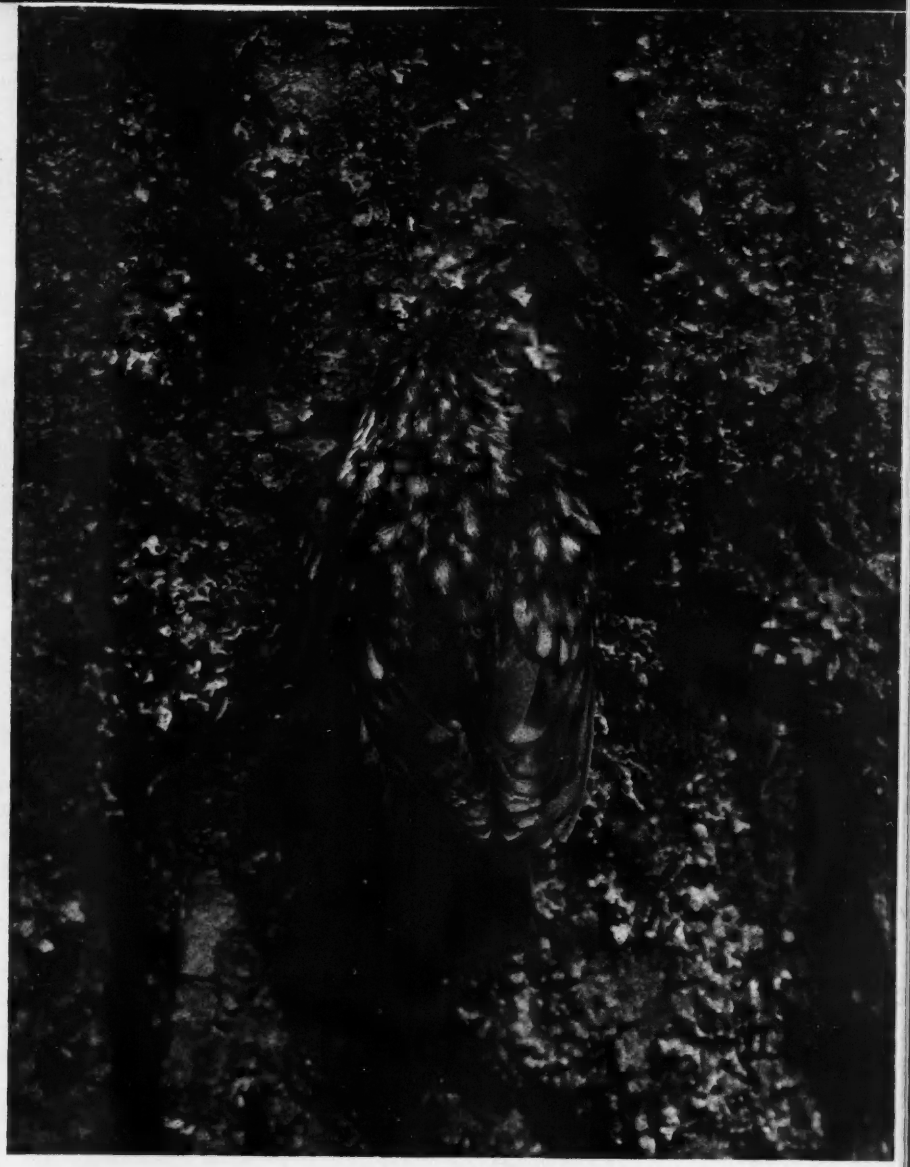
Fifth Columnists in the Insect World
HORACE DONISTHORPE F.Z.S., F.R.E.S.(Lond.)

Night Sky, July
M. DAVIDSON D.Sc., F.R.A.S.

Junior Science

The Bookshelf

Far and Near

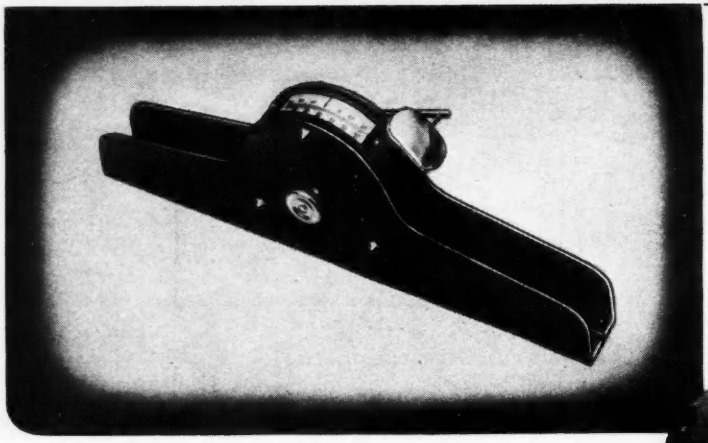


JUNE

1944

1/6

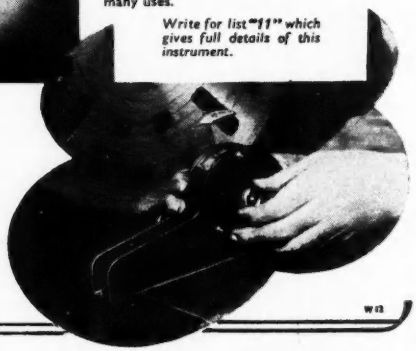
★ M.C. CLINOMETER ★



- Extreme Simplicity and Robustness.
- Dial locks for ease of reading.
- Low Drum Periodicity.
- 0–180° either way round.

All these advantages have been incorporated in the M.C. Clinometer which employs an improved pendulum principle. Even semi-skilled operators can, by its use, obtain accurate readings, and a further check is available by placing on the object first one way round and then the other. Illustration (below) shows the Mark V, M.C. Clinometer testing bed of newly installed lathe for twist—just one of its many uses.

Write for list "11" which gives full details of this instrument.



Sole Manufacturers & Distributors

E. R. **WATTS** & SON. Ltd.

Scientific Instrument Makers

CAMBERWELL, LONDON, S.E.5

Est. 1857

Aircraft Engineering

FOUNDED 1929

The Technical and Scientific Aeronautical Monthly

EDITED BY LT.-COL. W. LOCKWOOD MARSH, O.B.E., F.R.Ae.S., M.S.A.E., F.I.Ae.S.

Single Copies 2s. 3d., post free.

Annual Subscriptions 26s. 0d. per annum, post free.

PRINCIPAL JUNE CONTENTS:

The I.Ae.S. Annual Meeting. A. Klemin
Determining Intermittent Ratings H. Rissik
Automatic Power-Unit Controls. J. Lowrey
The Acetylene Thermoplastics. C. Fitzgerald-Lee
Moulded Plywood in Aircraft Construction. R. D. Hiscocks
Plastics in Engineering. W. Gallay

BUNHILL PUBLICATIONS LIMITED

12 Bloomsbury Square, London, W.C.1

When the Lights go up in Europe . . .

We must all be prepared to do our part in post-war reconstruction. You yourself can take an immediate step towards international understanding by learning Esperanto, the only established auxiliary language, already spoken by over a million people in a hundred different countries.

A complete correspondence course costs only 5/-, and is an enjoyable pastime.

Write for free particulars to-day.

THE BRITISH ESPERANTO ASSOCIATION Inc.
Dept. D.2, Heronsgate, Rickmansworth, Herts.

THE OBSERVATORY

A REVIEW OF ASTRONOMY. FOUNDED 1877

Edited by
H. F. FINCH G. C. McVITTIE
D. S. EVANS A. HUNTER

Annual Subscription for 6 issues, post free,

10/6

should be sent to The Editors, Royal Observatory, Greenwich, London, S.E.10

DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

June 1944 Vol. V No. 6 PUBLISHED AT THE EMPIRE PRESS, NORWICH, ENGLAND Tel. 21441

The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Science on the Air

"We are only the plumbers," said Sir Robert Watson in discussing the relation between science and broadcasting. He was emphasising the point that although the very possibility of broadcasting had come about as the result of the work of scientists, very little programme time was devoted to science. The function of the scientist seemed to be the anonymous one of making sure that ITMA, music and religion should be sent to the public in as competent a way as possible.

Since that remark was first made several changes, mainly for the better, have taken place. A number of purely scientific programmes have been radiated, including for example, the series, "Science Lifts the Veil" on the Home Service. This is a short step in the right direction, but it is a curious fact that as far as science goes—and perhaps this applies to the general intellectual level of the programme—the Home Service has lagged behind the others. One of the overseas services has for example long carried a short weekly programme under the title "Science Notebook": the Forces Programme included a few minutes of science each week in "Your Questions Answered", a feature now readily available to home listeners on the new General Forces Programme. The programmes for India and Latin America have included regular scientific features. Perhaps the best single solid chunk of science available to listeners on the Home Programme is the weekly feature in the Broadcasts to Schools, which is often put out in a lively and dramatic form.

The tale of all the scientific features included in all the programmes would be a long one, but measured by the total time available the broadcasting time devoted to it is not comparable with the present status of science. Few would deny that science is playing a part of peculiar importance in the events which are reshaping the world, and the man-in-the-street has a right to know what the significance of these new discoveries is. It may be that he does not realise that they may have any significance for him, but if this is so his interest in public affairs is the less well-informed, his power to exercise his rights as a citizen the less developed. If treated with the dignity which becomes him, he will not be put off by the fear that he might be educated through the medium of the radio, and will be eager to enlarge his knowledge. If then it is true that the significance of scientific discovery for social advance is lost on the average citizen, the BBC, which occupies a position of quite special importance as a medium of expression uncontrolled by commercial interests, ought to undertake a positive and bold policy of education.

One possible answer to this problem might be the institution of a regular scientific commentary on the news. Some of the biggest news stories of this war have been scientific ones—radio-location, penicillin and the rest of them. There are many others which could quite well have been more widely discussed without infringing the needs of security, enough in fact to provide a weekly quarter of an hour at the least. Such a programme could only be presented by a scientist, or by a group of two or three, who couple the knowledge of the expert with a great breadth of vision embracing not only a number of sciences, but an exact knowledge of the complex web of interconnections between science, its applications and its economic effects. Such men are available, although in wartime this same breadth of vision makes them invaluable in war-work, especially in connection with the type of problem rather off the beaten track which constantly arises in the application of science to the war effort.

However, in general, now that science has been recognised by all four estates of the kingdom as a phenomenon to be reckoned with, we may expect that an increasing number of scientists will find themselves in front of the microphone. These will include not only those known to the public for their outstanding work, but others perhaps known only to a relatively small scientific circle, who, as it were, take time off from the laboratory to explain what it is all about or to answer questions sent in by listeners. It is therefore desirable that scientists interested in this field should devote some thought to the method of presentation of their material.

The scientist, perhaps unfortunately, is most at home with the lecture as the means of communication of

knowledge, and is therefore prone to think of a 15-minute broadcast as a 15-minute lecture. This is not so. The lecturer can observe his audience and can pep it up a bit when he notices—a calamity that overtakes everybody sooner or later—that a man in the fourth row is sound asleep and that he is on the verge of losing contact with most of the rest. The lecturer can effect a last minute rescue from boredom: he can remove obvious perplexity by repetition: he can seize chalk and draw a diagram or two, and he can string his audience along with a succession of slides or even a film.

None of these aids is available to the broadcaster. He must foresee the dangers into which he may lead his unseen audience before the audience itself is aware that any danger exists. One way out—and examples of this will unfortunately leap to the mind—is to omit almost everything from the broadcast. This is not a very satisfactory solution, but it is an axiom that the number of facts per minute which can be intelligibly expounded without the aid even of gestures is rather small. The way out seems to be to include only a bare minimum of fact and to hammer home each point if not by direct repetition at least by parallel restatement and vivid examples.

There is, however, one form of exposition in which direct repetition is possible while retaining a naturalness of delivery. This is the dialogue form in which the unseen audience has one representative as a compère or interlocutor. The argument then proceeds smoothly, the compère acting the part of the stooge, or being struck (it is to be hoped with some show of realism) by suitable bright ideas at the correct moments. Then there comes a point where some crucial fact, perhaps a little difficult to grasp, must be stated. The dialogue form then enables the speaker to make his statement, the compère to take the difficult point up and repeat it in the same words and to ask for further explanation. The speaker then restates his point and proceeds to explanation. In this way, any particular salient fact of which special notice must be taken if the listener is to follow the rest of the argument can be stated no less than three times. It seems that this form is in many ways preferable to the straightforward exposition which is liable to miss its purpose if it contains too many facts, or become valueless if the attempt to lighten the exposition overshoots its mark and leads into triviality. Besides this, the continuous voice of the single speaker tends to have a slightly soporific effect, with consequent withdrawal of attention by the audience, perhaps at some crucial moment, which renders subsequent pronouncements valueless. The continual interchange and alteration of voices keeps the attention at the rather high level necessary for the absorption of scientific material, and the speeches of the compère also serve the function of giving the audience time to think—in the ideal case, time to think along the same lines as the compère. It is for these reasons that programmes such as the Brains Trust and "Your Questions Answered" have their effect, although the comparison between the two is not a fair one here, because the former is officially—and often is actually—a variety programme.

Much might be done in the exposition of light, interesting and valuable scientific material on present lines, especially if on occasion the programme consisted not only of voices, but, in the case when some audible recorder is used in an experiment, of the actual performance of the experiment in the studio as well. This was done on one occasion in "Science Notebook," apparently with very satisfactory results.

The greatest possibilities of all will of course arise when television returns. Even with pre-war sets diagrams and demonstrations will become possible, aided if convenient by all the flexibility of the photographed cinema film and the cartoon film. If, as we may expect, colour and stereoscopic television become possible an enormously powerful medium of public address will become available, the control and use of which will be matters of the deepest public concern. Without voicing any hostility to ITMA, it is to be hoped that a not-too-modest corner will be found in the programmes for first-class scientific broadcasts having the value for the listener not only of interest and instruction but social responsibility as well.

Potato Eyes

EVERYONE knows the old joke about the small boy who asked for potatoes with "Plenty of eyes, to see mother through the week." Few however realise the very important part potato eyes have played in seeing Russia through the critical years of invasion, or the part they are expected to play in restoring the food situation in Europe in the years immediately after the war.

Potatoes contain a very high proportion of carbohydrate, the energy-producing type of food, and, an equally important point, the yield per acre is higher than with almost any other crop which can be grown on a really large scale. They are therefore an excellent staple food in time of war when quantity must to a large extent outweigh appeals to the taste. Apart from their value as food potatoes are used extensively in industry for the manufacture of starch, glucose, acetone, industrial alcohol and other products. Accordingly, immediately following the German invasion of Russia in 1941, the government of the USSR ordered a large increase in the potato crop. This policy presented very serious practical difficulties. Apart from the huge losses of valuable agricultural land, which was by no means balanced by the loss of population requiring to be fed, it was impossible to provide the necessary quantity of "seed". In the ordinary way potato crops are raised by planting seed potatoes taken from the crop of the previous year. The seed potatoes sprout at the "eyes" and these sprouts give rise to the new season's plants. After sprouting the bulk of the seed potato rots in the ground. The order to increase potato crops meant that the growers would have to take more potatoes as seed, while at the same time circumstances demanded the greatest possible economy of existing supplies for use as food. Professor Lysenko and his colleagues at the Lenin All-Union Agricultural Academy have devised a satisfactory method of overcoming this difficulty. In their method the crowns of the potatoes, containing most of the eyes, are sliced off and used in place of the whole tuber. While normal seed must be sown at the rate of some 15 cwt. per acre, when crowns are used only 3 cwt. is required. There is therefore a saving of about 80%, the unused portion of the tuber being unimpaired for use as food or in industry. The crop is at least as good as when whole seed is used and in many cases appears to be less liable to

disease. In 1942, 250,000 acres were sown in Russia by the new method, while this was increased tenfold in 1943. As a result some 8 to 9 million tons of extra potatoes were obtained in 1943 without in any way reducing the quantity available for food and industry in 1942. For this work Professor Lysenko has been awarded the Stalin Prize for Agriculture. It should be pointed out that this method of propagation is not a new discovery. It has been well known to gardeners and nurserymen for many years and used on a small scale for the rapid propagation of types of potato showing particularly favourable characteristics. Unless planted very soon however, potato slices become infected with fungi and bacteria and fail to grow when planted. The value of the Russian work lies in the development of methods of cutting and drying the crowns by which they will withstand ordinary conditions of transport and can be stored for considerable periods. Not until these points had been fully worked out was the new method capable of being used on a really large scale.

Experiments have been carried out on similar lines in this country. Here the primary consideration has not been the relief of an acute food shortage but the possibility of saving transport. This factor is of course an important feature of the use of the method in Russia. It is well known that when potatoes are grown for more than one or two seasons in the same locality they become very prone to disease. For this reason most potatoes grown in England are raised from seed brought each spring from Scotland or Northern Ireland. The quantity involved is some hundreds of thousands of tons annually. If 70% or 80% of this bulk and weight could be eliminated it would be a considerable relief to our transport system. Far more important, however, is the supply of seed potatoes to certain of our overseas dependencies such as Malta, Palestine, Kenya and Nigeria, where the potato has been established as a farm crop. In many of these countries the heat prevents storage of seed even from one season to the next, while in all cases the incidence of disease requires the introduction of fresh stock from time to time. Under war-time conditions it has proved extremely difficult to maintain supplies. Too often shipping is not available at all, or all space is required for military stores, or as a result of delays the seed arrives too late for planting or in a spoilt condition. Examination of the possibilities of air transport soon showed that for ordinary seed this was quite impracticable, not only the cost but the weight and bulk also being prohibitive. The transport of "eyes" with a small piece of tuber attached has however proved quite feasible. As already mentioned 15 cwt. of seed is required to sow one acre while only 3 cwt. of eyes are required. After drying for seven days—a process which does not diminish their viability if properly carried out—their weight is only 1 cwt. There is therefore a reduction in weight of no less than fourteen fifteenths and a corresponding reduction in bulk. At present the method is being applied chiefly in the relatively close Mediterranean territories such as Malta and Palestine.

In America the "potato eye" trade is now well established, and it is rapidly coming into general use in Canada for supplying the more remote regions. The value of the method in the speedy re-establishment of European agriculture after the war is too obvious to need further discussion.

In conclusion, brief reference may be made to other experiments in unorthodox methods of potato propagation, with the common aim of preserving the tuber itself for use as food. Work carried out in Belfast since 1937 has shown that useful crops can be raised even from potato peelings scattered broadcast and lightly covered with soil. Professor Polunin, at Oxford, has shown that crops can be raised by allowing potatoes to sprout freely in trays and planting the detached sprouts.

Triangle Drama

THE nostalgic frequently remark with gloom that ours is a drab and ugly world, and sigh that they were not born in some mythical golden age in the near or remote past. But this is a superficial view, for of all ages ours is the richest in colour. The hues once reserved for emperors are to be had in the utility range. Fabrics, dyes, paints and cosmetics are available even in war-time in a bewildering profusion of texture and tint. The accurate specification of hues is thus clearly of the greatest importance to industries such as textile and paint manufacture, but in addition to this, manufactures associated with less vivid tones have a strong interest in the specification of colours. These include, for example, the brewery trade, where a standard shade is part of the specification of a sound draught, and the paper trade where a large range of subtle variations of whites and creams must be considered. Colour, too, has long had a place in science. A number of chemical tests for example depend on an accurate estimate of the colours of chemical indicators.

Thus from all directions comes a demand for some means of accurate specification of colour. Two problems present themselves. The first is to provide some means whereby any given sample of colour can be compared with a standard: the second is to set up some theoretical system for the representation of any colour so that an accurate numerical specification can be given.

The first is a practical problem involving the design of an instrument. The first of these was designed 60 years ago by a brewer, Joseph Lovibond, and consisted of nothing more than a tea caddy of a size adequate to hold two glasses of beer, in which rectangular slots were cut. This allowed the comparison of one glass of beer with another, but obviously some standard was required, and this was provided by Lovibond in the form of a series of amber coloured glass slides. In this way, any beer could be matched with a slide, and its colour specified by quoting the number of that slide in the series. However, while such a system of standards might be suitable for the comparison of a series of similar hues, something more elaborate was obviously needed for the comparison of any hue, and suitable series of standard coloured slides have been produced for very many classes of work.

It is at this point that knowledge of the nature of colour vision must be called into play. Many of the world's most eminent scientists have turned to this problem of colour vision, including Clerk Maxwell, Helmholtz, and John Dalton, the centenary of whose death falls next month. Although their findings have not been correlated with the anatomical structure of the eye, it is found that any colour can be regarded as being made up of varying proportions of three fundamental colours. Thus light of

any colour can be exactly matched by mixing together varying proportions of red light, blue-violet light and green. An important point to notice here is that this applies to coloured *lights*, and not to paints or pigments. A blue pigment for instance owes its blue colour to the fact that it reflects only the blue light, absorbing all the rest. If it were mixed with a pigment which reflected only red light, and therefore looked red, the mixture would absorb all the light and appear black. The pigments in the paint box do not satisfy these strict requirements, but

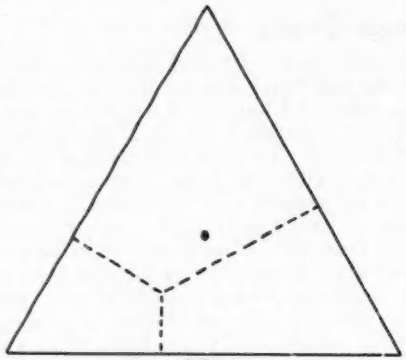


FIG. 1

a mixture of all of them does absorb all colours and therefore looks a dark grey, approximating to black.

It is therefore of importance to keep clear in the mind the possibilities of mixing colours by the addition of luminous sources, and the process of mixing pigments at each stage of which a further element is *subtracted* from the reflected light.

Once it had been established that colours could be represented as the sum of varying proportions of three fundamental colours, the accurate specification of colour

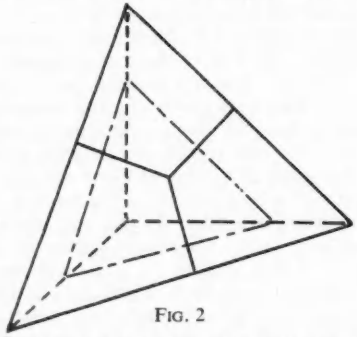


FIG. 2

became possible, three numbers being required to specify the mixture.

One way of representing these colours is by plotting them on an equilateral triangle whose side is taken as being of unit length (Fig. 1). Then for any point within the triangle the sum of the three perpendiculars on the sides is unity. (This is a method of plotting familiar in geometry under the name of "trilinear co-ordinates.) The vertices of this triangle may then be thought of as the source of the three basic colours.

The centre of the triangle then represents the point which receives equal contributions from all three fundamental components, i.e. it represents white. Increased displacement from any vertex corresponds to a reduction in the contribution from it. If a point were to travel across the diagram, starting at the point that represented the red of the spectrum, and moving towards white at the centre of the figure, it would represent a series of hues formed by the mixture of this red colour with an increasing proportion of white. Such colours are said to be more and more "unsaturated", the series representing a steady gradation of colour from red through paler and paler shades of pink to white. Thus if the position of the point representing any given colour can be plotted on the diagram the three components into which it can be analysed can be read off. Contrariwise a colour of known composition can readily be plotted.

A further quality of a colour, which can be represented by an elaboration of this diagram, is its brightness. This quality can be represented by making the original triangle the cut face of a corner cut off a cube, as in the diagram Fig. 2. Further sections parallel to the first one, and nearer to the corner would represent colour triangles of decreased brightness. The very small ones near the corner represent very low brightness and the corner itself is of zero brightness, i.e. black.

Such a representation of all colours in terms of three primary hues is of immense practical value.

The printer, for instance, who wishes to make an accurate reproduction of a painting first makes three photographs of it through three suitable coloured filters. This has the effect of splitting the hues of the picture into the three components. These three components are then printed in inks of suitable colour, their superposition on the paper —where of course each new layer produces a further subtraction from the reflected light—then gives a correct rendering, provided that the choice of the filters and the inks has been accurately made.

The advantages in all the varied types of work where colour is used of having a system for specifying any colour whatever in terms of three numbers and the brightness are clearly immense, and it is not to be wondered at that the study of colour is to an increasing extent engaging the attention of scientists.

Thyroid Hormones

ALL "ductless" glands produce substances, called hormones, which are passed into the blood stream. The thyroid, probably the best known of the ductless or "endocrine" glands, is situated just below the Adam's apple. Thyroid hormone is necessary for the proper development of children and also for maintaining normal health in adults. It plays a part in the regulation of the living processes of the body. Children with undeveloped thyroid glands grow very slowly and often never learn to talk; they are called cretins. Grown ups, whose thyroids fail, become stupid, slow in their movements, lose their hair and get baggy skin.

An over-production of thyroid hormone is more dangerous than under-production. People with a slightly too active thyroid tend to be unusually energetic and thin, often having rather bulging eyes. With a great deal more thyroid, they become restless and weak.

Lack of thyroid hormone is usually treated by administering it to the patient with some food. This may restore him to normal health. An over-active thyroid is sometimes dealt with by removing part of the gland.

The role of the thyroid as described here is not limited to human beings. It plays a similar part in the bodies of most other vertebrates. An interesting case is provided by the frog. This is a cold-blooded animal and, consequently, its temperature changes according to the weather. It stays roughly at the same temperature as that of its surroundings. But higher temperatures have the effect of speeding up the rate of beat of the heart. So in summer extra thyroid hormone is produced and this has a damping action on the heart, thus preventing too rapid a beat in response to the higher temperature. This phenomenon does not occur in animals with warm blood, like human beings, whose temperature remains roughly the same the whole time.

The heart can be removed from a frog and kept beating in a special salt solution supplied with oxygen. If thyroid hormone is added to the solution, the effect of temperature change on the rate of beat of the isolated heart will be altered. In this way it is possible to change a heart from its winter to its summer condition.

It is on the basis of these facts that some work was carried out recently at Cambridge, by Drs. G. S. Carter and G. Neil Jenkins, which may throw new light on the way in which the thyroid hormone works. They showed that there is a substance in the body which has an opposite effect to that of the thyroid hormone. This substance is called paraxanthine. Chemically, it is very much like caffeine, the principal drug in tea and coffee. It has been found in the livers of different animals and also in human urine. The energy output of an animal is probably controlled in part by the interaction between thyroid hormone and paraxanthine.

The addition of paraxanthine to the solution in which an isolated frog's heart is beating has the opposite effect to that of thyroid hormone. The heart reacts more violently to increased temperature. So if a "summer" heart is used, paraxanthine added to the solution will change the condition to that of a "winter" heart. But there is a limit to this effect. Too much paraxanthine causes a return to the summer condition once more. The effect of a given quantity of paraxanthine also depends on the amount of thyroid hormone present. When the quantity of thyroid hormone is doubled, it is necessary to double the amount of paraxanthine to produce a given effect.

Exactly comparable results were obtained in experiments with rats. Small doses of paraxanthine were given to them in their food every day and this led to a fall in their energy output, which may be measured with a piece of apparatus called a calorimeter. This fall of energy output increased with the size of the dose up to a certain critical level. When the dose was increased above this level, the energy output rose once more, until double the critical level was reached and at this point the energy became normal again.

It is of interest that large doses of paraxanthine do not appear to have any pronounced effects.

Mahomet's Coffin

In a recent issue of the *Proceedings of the Physical Society*, Lord Rayleigh describes his repetition of an experiment of Newton's which is readily carried out and might lend a quality of amusement and variety to the somewhat dull series of experiments usually employed for the demonstration of the principles of electrostatics.

Lord Rayleigh quotes from the minutes of the Royal Society for December 9th, 1675, in which the original experiment is described. Newton took a circular piece of glass about 2 inches in diameter and placed it on a brass ring lying on a table, so that there was a space of about one third of an inch between the glass and the table top. Under the glass were a few tiny scraps of paper, and when the glass was rubbed so as to produce an electrical charge on it, the scraps of paper were observed to execute a dancing and spinning motion.

Lord Rayleigh's repetition of the experiment was on a much larger scale. He took a sheet of brightly reflecting tin-plate which was placed horizontally and above it he placed a copper hemisphere, convex downwards, with a diameter of 13 centimetres. The distance between the lowest point of the hemisphere and the base plate was about 4 centimetres and the supports of the hemisphere were insulated. During the experiment the hemisphere was given a positive potential of up to 15,000 volts relative to the base plate by means of a Wimshurst machine.

Newton's scraps of paper were replaced by a small spinner of aluminium foil 0·05 mm. thick, shaped as an elongated isosceles triangle about 2·5 cms. in height with two small "ears" or lugs at opposite ends of the base. These lugs were bent out of the plane of the triangle at right angles in opposite senses, and the spinner was laid on the base plate.

On starting up the Wimshurst machine the spinner stands up on end and starts to turn as if the lugs were small propelling jets. With a higher potential the spinner is found to rise in the air remaining suspended—like Mahomet's coffin—between heaven and earth and spinning the while.

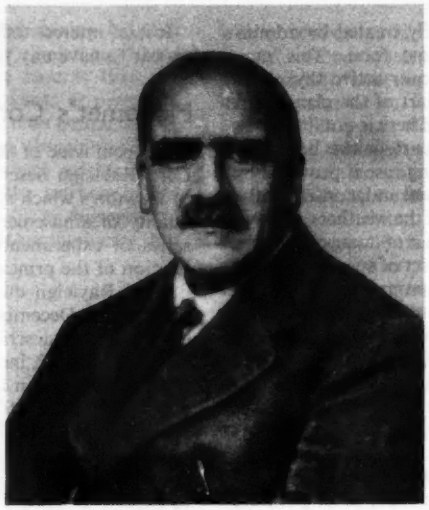
What happens is of course that the spinner acquires the negative potential of the base plate by contact and is then attracted into the vertical position by the positively charged hemisphere. The sharp points of the spinner where the charge density is greatest become the origin of electric discharges which can be seen if the experiment is performed in the dark. The reaction of these from the oppositely directed lugs produces the spinning action.

It is stated that the hemisphere should be made the positive pole as this lends greater stability to the motion; the hemispherical shape of the upper conductor also helps to preserve stability since the field is most concentrated beneath the lowest part of the bowl.

References

Triangle Drama: G. S. Fawcett, "Sixty Years of Colorimetry", *Proceedings of the Physical Society*, 1944, vol. 56, p. 8.

Mahomet's Coffin: Lord Rayleigh, "The Spinning and Floating of Light Bodies in an Electric Field", *Proceedings of the Physical Society*, 1944, vol. 56, p. 73.



Professor J. B. S. Haldane, F.R.S.

WILLIAM E. DICK

I HAD looked forward with pleasure to writing this biographical sketch of Haldane, but now that it is finished that mood of anticipated pleasure has given way to retrospective doubts. Haldane, as an outstanding personality of the contemporary scientific scene, could hardly be omitted from this series of articles. Yet Haldane has himself written so much and lectured so often about his work and his ideas that is seems almost an impertinence to intrude between the reader and the impressions of Haldane he will already have formed. However, in the course of collecting material towards this article I have come across quite a number of earlier pen portraits, and the fine crop of misconceptions and misrepresentations they contain convinces me that an article in DISCOVERY might serve to neutralise a few false impressions. I find, for instance, this epigrammatic remark by St. John Ervine: "Roughly speaking, Haldane may be said to be a Conservative when he is in the company of Socialists, and a Socialist when he is in the company of Conservatives. To a Primrose Leaguer he talks like a Bolshevist: to a Bolshevist he talks like a Rotarian." I took new heart on reading those words, for it would scarcely be possible to achieve a greater piece of rubbish than that.

Many of the comments that have been made about Haldane seem to me to lack perspective for the reason that they take no consideration of the period that forms the background against which Haldane has lived and worked. It should not be forgotten, for instance, that he belongs to a generation which fought out the Great War on the battlefield, and which then came back to a civilisation whose mood fluctuated between "bleak insincere optimism and hopeless desperation," as Wells has described it. For the first few years after the war the scientific world appears to have been relatively unaffected by post-war disillusion and cynicism, and the record of research is one of the few bright patches in the pattern of the 1920's. The next decade, however, brought the phase which has come to be known as "the frustration of science". That was a phenomenon real enough and revealing itself by many symptoms, complex symptoms that originated in a tangle of politics and economics. In France things became so bad that a stage was reached at which it was thought opportune to start selling postage stamps in a futile effort to provide doles for unemployed scientists, while in Britain the suggestion was made, quite seriously, that since the British Empire with all its great unsolved biological problems could not afford to employ biologists we should restrict the teaching of biology in our universities! With the coming of the Nazis and the consequent trend towards world war, even the internationalism of science (from which quite a number of scientists derived a measure of consolation during these unhappy years) began to shrink and lose its significance in a world where the only international organisation with any real power was concerned with the sale of armaments. That is the kind of world Haldane and his contemporaries have had to live in, a kind of world which he for one does not wish to see perpetuated. The general reaction of scientists to the events of that period was such that even the most conservative-minded among them became critical of the accepted order.

Small wonder is it that, as one of the spokesmen among progressive scientists, Haldane has from time to time ignored the polite conventions professors are expected to observe. He has never been able to maintain a scientific detachment when discussing such things as unemployment.

war, or the Nazis; and who would want him to, for these are subjects in which objectivity becomes indistinguishable from callousness. (In a democracy, in such an age, it is hardly possible to maintain the fiction that scientists should not meddle in these matters.) Haldane believes in stating his case, whether it be scientific or political, with vehemence; he does not mind changing his mind and amending his views when necessary, but it is quite remarkable that on fundamental things his ideas have weathered the passage of time better than those of many others.

Being One's Own Rabbit

Haldane was born on Guy Fawkes Day, 1892, the son of Professor J. S. Haldane, the physiologist. His sister, who is five years his junior, is Naomi Mitchison, the novelist. (I understand that she is at present engaged in compiling a history of the clan Haldane.) The late Lord Haldane was his uncle.

It was not long before the two children found their way to their father's laboratory, and the boy gained an early introduction to the science of physiology, being allowed to act as the subject of several experiments. Before he was nine, we find him going down a coal mine and learning the effect of breathing fire damp. "My father told me to stand near the roof and say something. I recited 'Friends. Romans and countrymen,' but before I got to 'the evil that men do' I tumbled down. That taught me quite a lot about fire damp. A little later the British Navy was so frightened of diving that the authorities said before a man could go down 40 feet he must have months of training. My father thought anybody could go down 40 feet at once and to prove it said 'Here is my son. He is only thirteen. Throw him overboard.' I went down all right, but the diving suit was too big for me, and when it was hauled up it was full of water up to the neck . . . . In that way I found things out." Which was certainly one way to arouse a child's scientific curiosity, and doubtless it helps to explain why Haldane has never hesitated to make experiments on himself. (His attitude towards self-experimentation is extremely well put in that classic essay "On Being One's Own Rabbit" (*Possible Worlds*, 1927), which every rabid anti-vivisectionist should be forced to read! There one can learn that there is no real danger in eating ammonium chloride by the quarter-pound even though it does result temporarily in "the type of shortness of breath which occurs in the terminal stages of kidney disease and diabetes". As Haldane himself says, "Experiments of this kind are safe enough if one treats oneself as a chemical system and makes no mistakes either in the calculations or the preparation of the chemicals to be eaten. If one makes mistakes of this sort the world contains one bad biochemist less".)

From Eton to "Daily Worker"

His more formal education he obtained at an Oxford Preparatory School and at Eton. His university career was interrupted by the Great War, on the outbreak of which he joined the Army. As an officer in the Black Watch he served in France and Iraq, reached the rank of captain and was twice wounded. With the Armistice he came home and was elected a fellow of New College, Oxford. One of his contemporaries at Oxford was Juliar Huxley, then demonstrating in the zoology department of the University. A few years later the two men collaborated to produce the useful book called *Animal Biology*.

The branches of biology which were developing most swiftly were physiology, biochemistry and genetics, and Haldane was attracted by all three. The all-round knowledge of biology which his studies in these subjects gave him was later to prove very valuable; for example, it enabled him to organise the team work—of organic chemists and geneticists—that was necessary before the way genes co-operate to produce plant pigments could be explained.

In 1922 Haldane moved from Oxford to Cambridge, where he had been appointed Sir William Dunn Reader in Biochemistry. One outcome of the work he did there was his monograph on enzymes. His next appointment was that of Fullerian Professor of Physiology at the Royal Institution (1930). There he remained until 1932, when he left to become Professor of Genetics at University College, London. 1937 saw him appointed the first Weldon Professor of Biometrics, also at University College. His F.R.S. dates back to 1932.

During all this time he was reaching with his writings an audience far larger than that of his immediate circle of colleagues and students. The first of his books, *Daedalus*, published in 1924, was a piece of scientific prophecy in the Wellsian strain. Most of his books must be well-known to readers, so there is little need to comment upon them in detail. Those written for the layman are almost certainly his most successful—he repeats his success at regular weekly intervals in the columns of the *Daily Worker*—and even his dearest detractors would be bound to admit that he has won his place as one of the most important publicists of science in Britain.

Political Profession

One may ridicule Haldane's philosophy, and one may ridicule his political views—but neither can be ignored. He is one of the few well-known scientists who makes no attempt to hide his political convictions, and that was true long before he joined the Communist Party in 1942. It is quite interesting to turn back the years and see how his political convictions have grown. In his book *Possible Worlds* he wrote: "If I thought that science in its present embryonic state could be applied to politics, I should become a politician. For the moment I believe that the man with the gift for thought on scientific lines is of more use to his fellows in the laboratory than out of it." But in the same essay he made the admission that "as a skilled manual worker and trade unionist, I have a strong idea where I should find my political affinities".

His attitude towards Russia has probably long been influenced by his political views, though he seems to have been pro-Russian long before he became a Communist. For instance back in 1928, when legend had it that all Russians were Nihilists and all Nihilists bomb-throwers, we find Haldane saying, "Russia is trying to inculcate a scientific outlook and habit of thought and is doing valuable research work especially in genetics, but I refuse to predict whether its form of national organisation will survive economic tests". (Hardly an excessive statement. Yet *Nature* was prompted to comment that the

Continued on p. 187

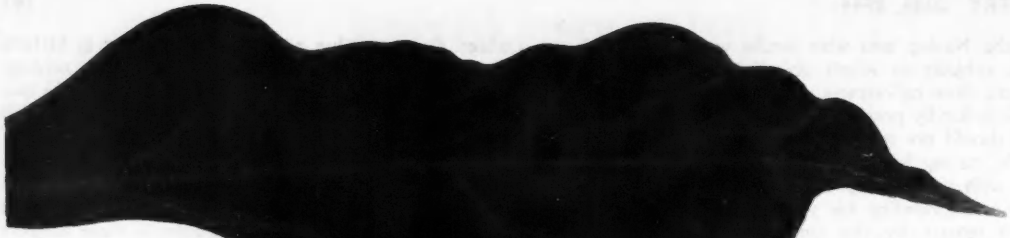


FIG. 1.—Tobacco mosaic, type or parent strain showing the characteristic dark green mottle.

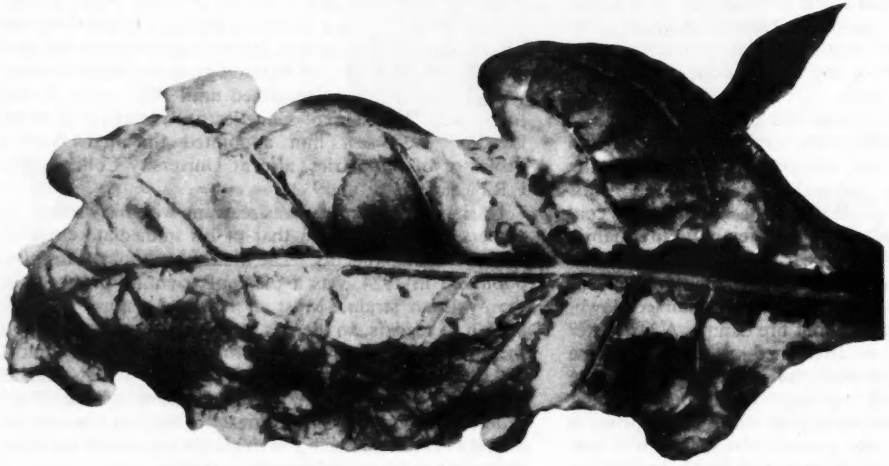


FIG. 2.—Tobacco mosaic, yellow variant or mutant, the light patches on the leaf are really bright yellow.

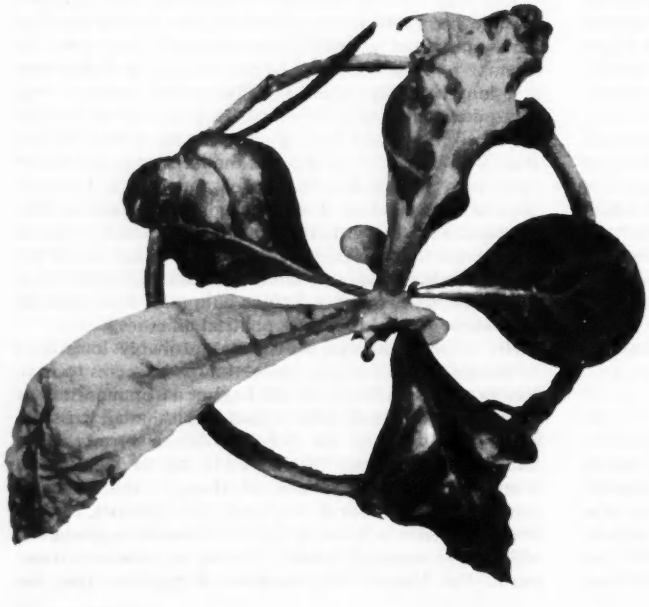


FIG. 3.—Tobacco mosaic, lethal necrotic mutant, the leaves are killed by the virus.

(All photos by Roy Markham)

Molecule or Organism?

KENNETH M. SMITH, D.Sc., F.R.S.

ONE of the first questions which the layman invariably asks the virus worker is, "Are viruses living things?" This is a difficult question to answer because there is no exact criterion of life. We can only say that viruses have some properties which are characteristic of "living" organisms and other properties which are more usually ascribed to "non-living" chemicals.

In this article I propose to describe some of these properties and in so doing will endeavour to give a brief sketch of some of the more interesting and outstanding discoveries which have been made about viruses in recent years. Let us first consider some of those characters which we usually associate with living things.

Multiplication of Viruses

There is no doubt that viruses possess to a high degree that fundamental power of multiplication which biologists tend to consider as an attribute only of life. This can be demonstrated by a simple experiment. The virus disease of tobacco, called "mosaic" (Fig. 1), is extremely infectious and is very easily passed from diseased to healthy tobacco plants. It is only necessary to dip a finger in the sap from a mosaic-diseased plant and rub it lightly over the surface of a leaf of a healthy tobacco plant for the healthy plant to become infected. This process is sufficient to break one or two leaf hairs, or trichomes, and so to allow the virus to enter the cells of the host. Incidentally I might mention here that a wound, however slight, even if it is only the breaking of a hair, seems to be necessary to allow plant viruses to enter their hosts. After the lapse of 10 days or a fortnight it will be found that the tobacco mosaic virus has permeated the whole plant and is present in the stem, leaves, roots and flowers but not in the seed. The tobacco plant now contains a considerable quantity of virus and this represents a high degree of multiplication when the size of the initial dose is remembered.

There is one characteristic in the multiplication of viruses which differentiates them sharply from bacteria or fungi. They can only multiply *inside a living cell*. No one has yet succeeded in getting a virus to multiply in or on any kind of nutrient medium such as an agar slope which does not contain living cells.

We know then that viruses multiply but unfortunately we know practically nothing of *how* this multiplication takes place. It probably is a form of synthesis of the existing plant proteins but more than this we cannot say at the moment.

I have said that viruses must have a living cell in which to multiply but it does not matter if the living cells are not themselves attached to the main organism. It is the living cell that matters. This means that viruses can be cultivated in small pieces of living tissue which are themselves being grown in a nutrient medium. This method of growing viruses in "tissue cultures" has yielded information of great interest and practical importance and we shall have occasion to refer to it again later.

Inactivation of Viruses

In common with bacteria, viruses are fairly easily killed, inactivated is a better word. They are destroyed by heat, by common disinfectants and by extremes of *p*H. of the virus solution. This means that the virus cannot stand very acid or very alkaline solutions.

Some viruses, especially those attacking plants, vary greatly in their susceptibility to heat. For example, the virus of tomato spotted wilt is destroyed by 10 minutes' exposure to a temperature of 42°C., while that of tobacco mosaic is only destroyed by 10 minutes' exposure to 93°C.

You must understand that I am referring now to the virus in solution after it has been extracted from its host. It is very much more difficult to destroy a virus in its host and thus effect a cure without harming the latter. Nevertheless in certain cases it has been found possible to effect a cure by means of heat treatment. This of course can only be done with viruses which are destroyed at a comparatively low temperature. L. O. Kunkel has carried out some interesting experiments on these lines with plant viruses. He found that by growing young peach trees infected with certain viruses at a high temperature, he was able to rid the trees of the virus although he had great difficulty in destroying the virus in the roots.

Plants themselves vary in their capacity to withstand heat and it may be possible to destroy a particular virus in one host but not in another. A good illustration of this is given by a virus disease of asters known as "aster yellows". The aster cannot be submitted to heat treatment because this plant will not endure high temperatures but the aster yellows virus can be destroyed in the periwinkle which will stand up to a fairly high temperature. In these experiments infected periwinkle plants were freed of virus by immersion in a water-bath held at a temperature of 40-45°C. for a few hours. Such cured plants are of course still liable to re-infection with the same virus since plants do not develop an acquired immunity in the way that animals do. It is interesting to find that Kunkel was also able to destroy the aster yellows virus in the insect—a leafhopper—which transmits it. Subjecting the infective insects to a temperature of 36°C. for about 8 days rendered them non-infective when tested on healthy aster seedlings.

Variations or Mutations in Viruses

We know that variations, or *mutations* as they are called, occur commonly enough in living organisms and we know that they appear suddenly and breed true. Now apparently similar variations occur quite frequently in viruses, though we do not know if they are, strictly speaking, true genetical mutations. Two common examples of such variations in viruses will suffice as illustrations. When a child is vaccinated against smallpox, he is inoculated with *vaccinia*, a variation of the true smallpox, *variola*.

Tobacco plants infected with the mosaic disease frequently develop one or more bright yellow spots on the leaves. If such a yellow spot is carefully cut out without any of the surrounding tissue and inoculated to a healthy

tobacco plant, a different disease from that shown by the original plant is produced. The variant mosaic virus produces a bright yellow mottling (see Fig. 2) which is frequently fatal to the plant instead of the milder light and dark green mottling of the type disease.

Mutations can also be induced in viruses by artificial means such as heat treatment, passage through unusual or abnormal hosts and by tissue culture.

The experimental production of virus mutations is not, as it may seem at first, merely of academic interest. Let us examine a little further these mutations and the methods used in their production and see why they are of importance.

The great benefits which can derive from the use of virus strains was first demonstrated by Jenner when he used the virus of cowpox (vaccinia) to immunize patients against smallpox (variola). Nowadays attempts are made to produce mutations of many viruses in order that the mutants may be used for protective inoculation. Among the methods used for producing virus variants two are outstanding, passages of the virus through unusual hosts and, what is really much the same thing, tissue culture of the virus.

The West Coast of Africa was long known as "the white man's grave", the chief reason for this being the prevalence of that dreaded virus disease, yellow fever. That it no longer deserves that name is partly due to the ordinary mouse which has had a large share in bringing about this happy state of affairs. In 1930 M. Theiler found that the virus of yellow fever could be altered by passage in mouse brains. Later the virus was modified still further by passage in tissue culture until a strain known as 17D was evolved which was suitable for vaccination purposes. In 1942 over 4,000,000 people were vaccinated with this modified virus.

Another interesting example of the production of a variant virus by cultivation is given by the virus of epidemic influenza. In this case, however, the developing hen's egg was used as a culture medium for the virus and F. M. Burnet succeeded in making a strain of influenza virus from ferrets grow on the egg membrane. At first the virus was quite innocuous to the chick embryo but after a large number of serial transfers from egg to egg, the virus began to attack its new host and finally became so virulent that the embryo was killed in 2 or 3 days. The interesting point, however, is that the virus lost virulence for man as it gained virulence for the chick, so that one is encouraged to hope that one day a vaccine against influenza may be produced. One of the chief difficulties in the way, however, is the fact that the influenza virus occurs in so many different strains which do not immunize against each other. So that even if a vaccine were produced it would only protect against one particular strain of virus which might not be the one prevalent during an epidemic of the disease.

Tobacco mosaic takes its name from the light and dark green mottling of the leaves which has some resemblance to a mosaic pattern (see Fig. 1). Now a variant of this virus has recently been obtained which does not produce a mosaic mottling at all but instead kills its host by destroying the tissue (see Fig. 3).

We have learned then that viruses multiply inside their hosts, that they are easily destroyed or rendered non-infective when extracted and that they change spontaneously into related but slightly different forms. These are all characteristics commonly associated with what we call living things. Let us now examine certain other characteristics of viruses which are perhaps more suggestive of a chemical substance.

Purification of Viruses

Until comparatively recently the chief evidence for the existence of viruses, especially of plant viruses, lay in the diseases they produced. It was known that viruses existed, that they gave rise to diseases and multiplied in the process and that they could be passed on indefinitely from host to host. But there for long the matter had rested. Attempts had been made from time to time to separate the virus from its host tissues but with little result until 1935 when W. M. Stanley succeeded in isolating the virus of tobacco mosaic in a comparatively pure state. He did this by employing the salting-out methods used to isolate enzymes and for the first time it became possible to correlate the activity of a virus with something tangible.

The substance which Stanley isolated from the sap of mosaic-diseased tobacco plants was a crystallizable protein of very high molecular weight, a nucleo-protein as it is called, containing phosphorus. When comparatively pure this virus protein has an intense satin-like sheen which, with other properties, indicates the presence of elongated particles.

When this substance was first isolated there were many who thought that it merely carried the virus attached to it and that it was not the actual virus itself. Now, however, there are few who hold this opinion; exhaustive tests have indicated that protein and virus are one and any treatment which reduces the protein, reduces the infectivity at the same rate. Moreover, this substance can be obtained from plants botanically quite unrelated such as the tobacco and the phlox but it cannot be obtained from any plants which are not infected with the tobacco mosaic virus. During the last few years several other plant viruses have been isolated and crystallized (see Figs. 4 & 5). Many plant viruses, however, are difficult to concentrate and purify because they do not occur in their hosts in sufficient quantity. Such viruses may cause very severe diseases and may be fatal to the plants they infect but severity of disease does not necessarily imply the presence of large quantities of virus. So some plant viruses must await the development of improved methods of isolation.

Chemical methods of virus purification such as those used by Stanley involve rather drastic treatment of the virus and may cause much loss of infectivity of the virus. There is another method, however, by which viruses may be isolated without submitting them to chemical treatment. Since most viruses appear to be proteins of high molecular weight it follows that they can be sedimented out of solution by centrifugal force. This means that if a virus solution is spun in the high speed centrifuge at a speed of say 25,000 revolutions per minute, the virus is thrown down to the bottom of the tube and can be collected in that way.

Virus Crystals

In 1903 D. Iwanowsky, the discoverer of viruses, showed that some of the cells in the leaves of mosaic-diseased tobacco plants contained numerous crystals. Now although

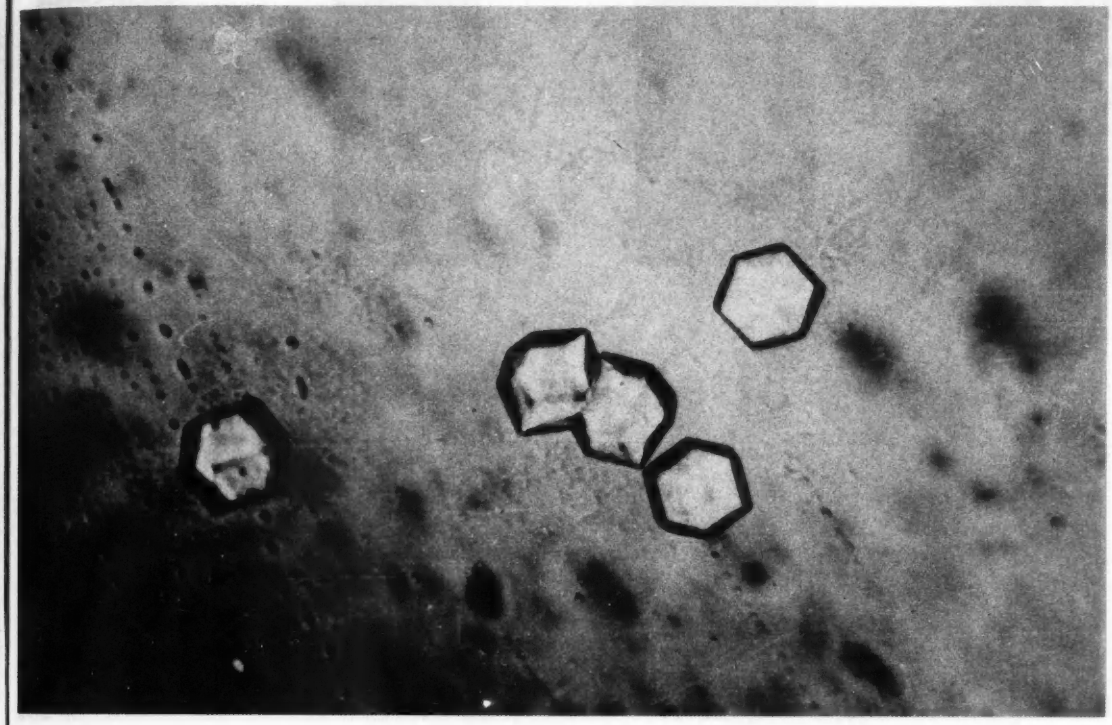


FIG. 4.—Crystals of tomato bushy stunt virus.

Iwanowsky had no idea of it, those crystals were almost certainly the mosaic virus itself which had been induced to crystallize by the acid fixative used in making the preparation of the cells. We are only able to draw this conclusion because of the similarity between these crystals in the cells and those which Stanley obtained with his purified preparations of tobacco mosaic virus. These very small needle-shaped crystals are not, strictly speaking, true crystals but are only two-dimensional and are known as paracrystals. This, however, need not concern us here.

In 1938 F. C. Bawden and N. W. Pirie purified and crystallized a virus which attacks tomatoes and is known as the tomato bushy stunt virus. This time the crystals were true three-dimensional crystals in the form of rhombic dodecahedra (see Fig. 4). Shortly after this another virus, that of tobacco necrosis, was isolated and crystallized in the form of thin lozenge-shaped plates which are fragile and easily broken (see Fig. 5).

So far only certain small plant viruses have been obtained in crystalline form; animal viruses have not yet been crystallized and it is probable that the larger animal viruses such as vaccinia will be found incapable of crystallization.

It must be admitted that in the mind of the biologist the power to multiply and the phenomenon of crystallization do not fit well together. It seems therefore as if he will have to readjust his conception of life and, like Aristotle, visualize a gradual transition from the inanimate to the animate kingdom with only a doubtful and indistinct boundary between the two.

Size and Shape of Viruses

You may think that to measure accurately the size and shape of something which is too small to be seen is an impossible task. Nevertheless, it can be done by using some of the exact methods of the physicist but the number of viruses of which the size can be measured is limited because certain conditions must be fulfilled. The virus should be fairly stable, i.e., not easily inactivated, occur in high concentration and in the case of plant viruses should be transmissible by sap-inoculation.

There are various ways of calculating the sizes of viruses; by measuring the rate at which the virus particles sediment in a centrifugal field; by diffusion; by filtration in which the virus solution is passed through filter membranes in which the size of the pore is known; by X-ray diffraction and by ultra-violet light and electron microscopy. All these methods are extremely technical and any attempt to describe them would be out of place here. It may be of interest, however, to discuss very shortly some of the results obtained by these methods. The first thing which strikes one is the wide variation in the sizes of the different viruses. Vaccinia virus is one of the largest measuring about 235 millimicrons (one millimicron—represented thus, mμ,—equals one-millionth of a millimetre). This virus

FIG. 5.—Crystals of a virus causing tobacco necrosis.

comes almost within the limit of resolution of the ordinary microscope. The smallest animal virus seems to be that of foot-and-mouth disease which is said to measure only about 12 mμ. Most of the plant viruses which have been measured are very small, two of the smallest being 37 and 16 mμ respectively. These viruses, mentioned so far, are spherical in shape; some of the plant viruses, however, are not spheres at all but long rods and this fact, of course, has complicated the business of measuring their size. It had long been suspected for example that the virus of tobacco mosaic was a rod because of certain optical properties of the virus in solution. This was confirmed by the X-ray diffraction studies and by the electron microscope, an instrument which has given us much information on the sizes and shapes of viruses. Put very briefly, the electron microscope does not use light at all but uses instead a beam of electrons which has a wave-length very much shorter than that of light. This enables particles of about 5 mμ to be resolved and thus photographs have been obtained of some of the smallest plant viruses.

The first virus to be photographed with the electron microscope was that of tobacco mosaic and these pictures confirmed the earlier belief that the virus was a long thin rod. They showed the individual rods to be about 15 mμ in diameter and about 300 mμ in length, but the length does not appear to be always the same in different preparations of this virus.

Another plant virus to be photographed was the tomato bushy stunt virus and this, as already suspected, was shown to be a sphere; it measured 37 mμ in diameter.

An interesting and unsuspected result was obtained in photographing certain bacteriophages which are virus-like agents attacking bacteria. These photographs revealed that the bacteriophage particles were neither spheres nor rods but consisted of a round "head" and a much thinner "tail", giving the appearance of minute tadpoles or spermatoza. According to S. E. Luria and T. F. Anderson the bacteriophage particles appear to stick to the bacteria either by the head or the tail and the number which stick in this manner increases with the time of contact.

I have called this article "molecule or organism" but in order to be considered as molecules, the virus particles must all have the same chemical properties and they must all be identical in size and shape. Now as we have seen the particles of tobacco mosaic virus are all the same thickness and they are chemically homogeneous but they seem to vary in length. At all events we are not certain what is the exact length of the tobacco mosiac particle. So this virus does not fulfil the definition of a molecule. There is another virus, however, that of tomato bushy stunt which we have already mentioned as forming true crystals and this has spherical particles, all of which are of identical size and shape. So that this virus does seem to fulfil the conditions of our definition of a molecule and it has, of course, as well the power to multiply inside a susceptible plant. And at present that is about as near as we can get to an answer to the question with which this article opened: "Are viruses living things?"

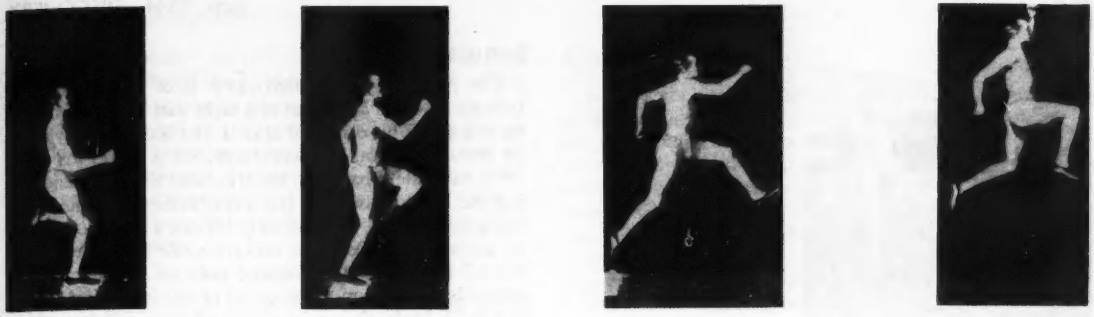


FIG. 3

Science and Athletic Events

G. T. P. TARRANT, M.A., Ph.D.

ALTHOUGH man has, in the past, learnt to excel in athletic events mainly by a process of trial and error, it may well happen, in the future, that scientific calculations will also give valuable assistance. The fundamental principles of mechanics must apply to the movements of our arms and our legs as well as to the machines and apparatus of the laboratory. If we wish to throw a cricket ball or a javelin at our maximum range, we must throw at the same angle of 45° as a shell is fired from a gun to get its largest range. If we prove that the range of the shell is $\frac{v^2}{g} = \frac{2fs}{g}$*, we may use the same formula for the cricket ball or for putting the weight. The biggest difference is that with artillery it is only the shell that is made to accelerate, whereas, in throwing, it is both the object and about 4-lb. of hand and arm. Thus, the acceleration f is :

$$\frac{\text{force of arm muscles}}{(\text{mass of object} + \text{mass of arm})}$$

and the range is:

$$\frac{2(\text{force of arm muscles})\ (\text{arm length})}{g(\text{mass of object} + \text{mass of arm})}$$

The term "mass of arm" is probably a little greater than the true mass of the arm because during a throw the movement of the arm consists not only of a transport of the limb, but a swinging or bending movement as well. The result is actually to increase the effective mass of the arm.

Fig. 1 shows how well this formula seems to fit the facts of world-record throws of the weight, the discus, the javelin and the cricket ball, since all of the points lie close to the straight line. Agreements such as this cannot be fortuitous. We must accept them as evidence of the ability of mechanics to analyse in a general way the athletic operations of our body. Having established our bona-fides, let us go on to consider some of the many problems that athletics presents. The first obvious point refers to the variation of gravity over the world.

The value of gravity enters into the above formula and to those of most other athletic performances; and gravity is about ½% less at the equator than it is in the temperate zones. This is sufficient to make a 255-ft. javelin throw some 6 inches greater at the equator and to increase a long jump by about 1¼ inches. Incidentally, at the equator, there is an additional effect due to the centrifugal force of the earth's rotation being increased or decreased when the projected body is moving respectively towards the east or west. This will lead to an increase in range of over 2½ miles with a 60-mile shell.

*v denotes the muzzle velocity of the shell, g the acceleration of gravity, and f and s the acceleration of the shell in the gun and the length of the barrel respectively.

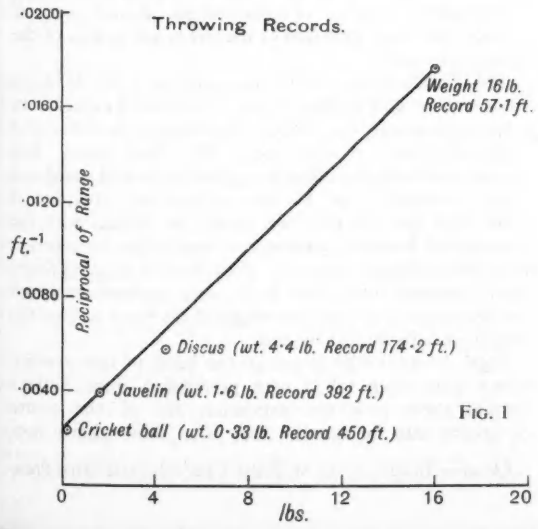


FIG. 1

FIG. 2.

Jumping

The problem of the high jump is of greater interest, because it would appear at first sight that a jumper should be able to lift his centre of gravity in a jump by only some 24 inches, whereas the world's record is 6 ft. 7 ins. The 24-in. estimate is based on the argument that by straightening the body at the hip and straightening the knees and rising on the toes, one can only lift one's centre of gravity by about 12 inches. The upward velocity we acquire in this 12 inches will then depend only on our acceleration upwards—that is on the strength of our leg. Now it does not seem likely that even a trained man will be able to support, be it only for an instant, *on only one bent leg*, a weight on his back greater than twice his own weight. Thus, when jumping, he cannot produce in himself a greater upward acceleration than $2g$ and so cannot jump higher than twice 12 inches.

The anomaly is still not explained completely by arguing that the jumper's centre of gravity is already some 3 feet in the air when his toe first left the ground, so that by simply lying flat over the bar he should be able to clear that 3 feet without jumping at all, because this would still give a limit to the world's record jump of about 5 feet.

The last 18 inches of the jump are obtained by careful use of leg and arm swings. While still standing on the ground in a crouched position the jumper swings one leg upwards with great speed. The resulting upward momentum is then transferred to the body an instant afterwards when the body has just lifted from the ground. But the whole secret of the champion can be shown mathematically to depend on the timing of these swings. The upward swinging of the leg and arms must reach their upper limit just at the very instant that the jumper has left contact with the ground, because it is then that he is moving upwards with the greatest speed and the energy which can be transferred by the effective impact of the legs is large only when he is moving rapidly upwards. Thus if the timing is perfect the swings will lift him an additional 18 inches, whereas if the upward swings reach their end before he has started to rise they would lift him no more than 3 inches.

The mathematical analysis indicates plainly that very considerable increases in total height should occur if 4 lb. of sheet lead were tied to the wrists and ankles of the swinging members.

The world's record for the long jump is 27 ft. 2¾ in.—a value very much less than the 36 ft. we should expect from our mathematics if the jumper is combining a world-record high jump with a world-record for sheer speed. The jumper has to choose between a great horizontal speed and a great vertical jump. He cannot have both, because at high speed his foot does not remain in contact with the jumping-off board long enough to enable him to generate his greatest upward velocity. Providing he is going faster than a certain minimum value, any increase in speed merely serves to reduce the height of his jump so that the length remains much the same.

Figs. 2 and 3 (the latter at the head of this article), which have been taken with permission from Butler's book*, show how the maximum lift of the centre of gravity can be found. They also show clearly how

**Modern Athletics*, by G. M. Butler, Cambridge University Press.

leg and arm "swings" may be employed. With the foot flat on the board and the knee bent, the arms are swung up—the one forward of the body and the other behind it—so as to preserve balance. Bringing the leg upward gives the additional lift required; bringing it forward tends to keep the body back over the board until knee and toe have had time to straighten out, and then afterwards, as it is brought to rest relative to the body, increases the horizontal velocity of the jump.

Running

The human body is ill adapted for the continuous production of power. Even in the old-fashioned treadmill the convict only produced an average power of about 80 watts. Thus human labour has rapidly been replaced by electrical motors whenever possible. Human labour costs at least 1*s.* for 80 watt-hours, whereas electrical power would only cost $\frac{1}{24}$th of a penny. Yet the human body surpasses all machines in its capacity for dealing with overloads for short periods. A member of a boat race crew may produce 370 watts for the short period of a race, and a sprinter may do work at a rate of 2,500 watts or 4 horse-power for the 10 seconds or so of his race. What an amazingly high rate this is, especially when we remember that it can be shown that human engines are only 25% efficient!

This enormous power produced in sprinting is largely spent in the mechanical work of accelerating and retarding the legs at each stroke, since the energy supplied to accelerate a leg is lost and is not recovered when the leg is brought to rest.

A sprinter doing 7 ft. strides at 35 ft. per second puts each foot to the ground at time intervals of $\frac{1}{5}\frac{1}{5}$ sec. If the foot is in the air for only half of this time, it undergoes its acceleration and retardation in only $\frac{7}{55}$ sec. Thus, in accelerating from rest, the foot covers 7 feet in $\frac{7}{10}$ sec. and so the acceleration is 44*g*.

This, with a leg weight of 8 lb., needs a force at least 240 lb. weight. The kinetic energy of this rapidly moving leg is so large that in a 100-yard sprint done in 10 sec. the horse-power required to accelerate the legs is 3·4.

In this connection, the general disposition of the muscles is of considerable importance. It will be noted that—probably as the result of some evolutionary process—the muscles have come to be housed in parts which are not subject to these great accelerations, and which therefore need smaller forces and a smaller horse-power to maintain at the necessary speed.

Cycling

Cycling enables the rider to cover ground easier and at a greater speed than when running, because the foot moves far less rapidly and needs less energy for its accelerations. Furthermore, there is no need to waste energy in slowing down the rapidly moving downwards leg. All of its kinetic energy will go to the pedal system if one simply pushes less hard. The foot itself while moving at a constant speed consumes no energy, for it is moving in a true circle about a firm centre and obtains the necessary forces from the pedals

The art of balancing on a cycle is the art of countering at a very early stage each incipient wobble by turning the handle-bar slightly so that the bicycle moves in the arc of a circle, and the corresponding centrifugal forces push the centre of gravity slowly back to the upright and over to the other side. Thus, as centre of gravity continually falls off on alternate sides, so does the path change from being an arc of a circle on one side to an arc on the other.

An expert rider can balance at speed without holding the handle-bars by bending his body sideways, since this action tilts the cycle out of the vertical plane and makes the handle-bars move in the required direction. The problem is thus the same as the problem of answering how a man can push a cycle along a road when he is holding the seat and, not the handle-bars. Four separate sets of forces operate, but of these only two are important. The most important is produced by the weightof the front wheel and handle-bar unit being in front of the sloping axis of the steering column, while the second is the gyroscopic action of the front wheel which becomes increasingly important as the speed is increased.

The theory of gyroscopes enters into more athletic subjects than the action of the bicycle. It is needed to explain some of the evolutions of the high diver, the juggler, the dancer, and the skater. Simple physics throws light on the size of birds, gives the size limits of warm-blooded animals, and shows how to increase safety in rock climbing. But we have far to go before athletics and human activities generally cease to provide new and interesting problems to the physicist.

[More detailed accounts of the problems discussed above are given in "Mechanics of Human and Animal Activity" by G. T. P. Tarrant, in the *School Science Review*, December, 1938 and March, 1939. An article on "The Mechanics of the Bicycle" is appearing shortly in the same journal.]

Mathematics and Industry

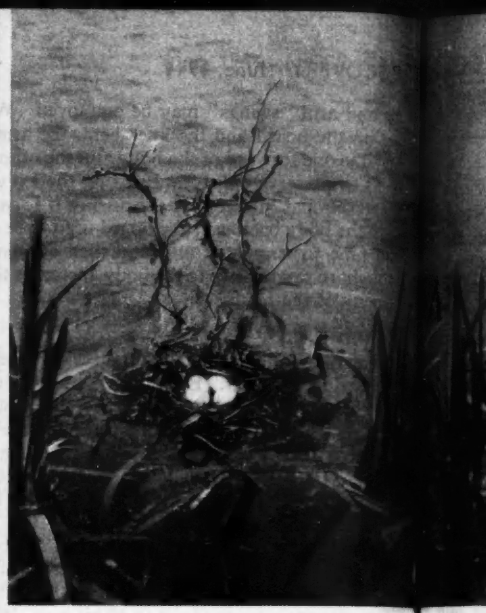
THE following letter has been received from Mr. W. W. Sawyer of the Mathematics Department, The University, Manchester. Mr. Sawyer is the author of the Penguin *Mathematician's Delight*, and has some extremely original ideas on the teaching of mathematics. Here he proposes a piece of "operational research" to find out exactly what sort of mathematics is needed in industry:—

In DISCOVERY for October 1943, "J.S." described how much academic training in chemistry was out of touch with the actual needs of chemists in industry. This isolation of theoretical and practical activity is not confined to chemistry: it applies equally well to engineering and to most forms of applied mathematics. Mechanics books, for instance, are full of examples which have no relation to practical life: they are put in because they can be solved by mathematics and make good "examples".

Many school teachers and university teachers would like to remedy this state of affairs, but we can not do it without the help of practical workers. We need, for instance, textbooks with examples drawn from actual problems in real life: mathematics could be taught from arithmetic upwards in such a way, and would have far more interest and purpose for the average boy. To write such a textbook a number of workers in industry would need to get together and keep a diary of the problems that confronted them—those they were able to solve, and also those which defied solution. A number of mathematicians would then need to study these lists, and classify the problems according to the mathematical knowledge each required. Textbooks could then be written, and students of applied science would know that they were not wasting their time in reading these. Teachers also would have more confidence that they were not wasting the time of students. I know, for instance, that a research worker can hardly know too much mathematics: *but does the average engineer need to know any mathematics at all?* If so, what for? We tend to be fifty years behind the times in what we teach. The sheet metal worker needed all kinds of mathematics fifty years ago: does he still to-day?

Another way of finding real examples is to go through the past issues of technical journals. This is quite easy, though it takes time. In war-time conditions of work, quite a number of people would have to co-operate to get any useful result at all quickly.

Is there any scientific or industrial body that is prepared to organise this work?



Nature's Camo lage

MR. REGINALD GAZE, whose pictures and observ s on natur collection of photographs various aspects of ca age to be picture is of a Tree Creeper blending in marvello ith the ba second, which is reproduced by courtesy of Fab Faber Ltd shows a Little Grebe's nest of decayed vegetat n the surf nest the bird covers her eggs by heaping loose n material about 20 seconds in this instance. The third pic shows hov with the light streaking of her head and back s her almo grasses of the marshes amid which she nests. e four sho scorched grasses. In spite of her large size sh t easily white in plumage never comes to the nest where uld be see crested ocean he blends in perfectly. Picture f of a Lapp tinguishable from its background. Picture six sh ow the wa perfectly with the rough bark of a tree trunk. last pictu the dead bracken, so closely resembling a piece d wood th

's Camouflage in Britain

ictures and observ on nature are well known, shows in this small ous aspects of cam ge to be found in our country-side. The first nding in marvello ith the bark and lichens of the tree trunk. The y courtesy of Fab Faber Ltd. from Mr. Gaze's *Look at this Bird*, f decayed vegetat n the surface of the water. When leaving the y heaping loose n material over them with her beak; it took her ce. The third pic shows how the long beak of the Snipe together head and back m s her almost indistinguishable from the course hich she nests. P e four shows the Eider Duck on her nest in the her large size sh ot easily detected. The male bird, black and to the nest where uld be seen from a great distance; on the foam fectly. Picture fi of a Lappit Moth, which here is almost indis- nd. Picture six sh ow the warty skin of a toad harmonises almost of a tree trunk. last picture shows a Night Jar nesting among sembling a piece d wood that it is an easy matter to pass her by.

The Scope of Microchemistry

DAVID L. MASTERS, M.Sc., Ph.D.

DURING the last twenty years, a number of chemists have turned their energies to the carrying out of chemical processes on a scale so small that it approximates quite nearly to the physicist's extreme of atomic dimensions. This new branch of scientific investigation has quite naturally come to be known as microchemistry—chemistry on a small scale. Thus, where the ordinary chemist deals with anywhere from a tenth of a gramme up to several grammes of solid material (a penny weighs about ten grammes), or with litres (a litre is about two pints) and millilitres (thousandths of a litre) of liquids and solutions, the microchemist will probably handle quantities which are one thousandth part of these.

In order to do this capably, it is easy to realise that a worker must alter his whole outlook on practical manipulations. For this reason, it has often been maintained that microchemistry is the result of an attitude of mind rather than of any specific advance in technique. This, of course, like all sweeping generalisations, is by no means wholly true. But there is undoubtedly a strong element of truth in it. It may be expressed in this way. If a chemist has the proper attitude of mind, he will be able to carry out work which could properly be classed as microchemistry, even though he has available only the most makeshift apparatus, amounting only to a few bottles and pieces of glass tubing. But if the chemist has not achieved that essential re-orientation, then he may be blessed with the most perfectly equipped microchemical laboratory in the world, and his tools will never enable him to engage in the study of microchemistry. Some essentials of that attitude of mind will become apparent when the technique of microchemistry is discussed in more detail.

It has been pointed out that a microchemist will probably handle quantities of material of the order of one-thousandth of those usually considered suitable for chemistry. This should be amplified somewhat. There are really several levels of microchemistry. In its strictest sense, microchemistry will deal with such problems as the chemical analysis of from two to five thousandths of a gramme of a substance. If this is weighed, it will be weighed to the nearest millionth of a gramme, or microgram (μg.). Since then, the unit most usually met with is a milligram, this branch is often referred to as milligram chemistry.

Lying between this region and that covered by ordinary chemistry, there is centigram chemistry, which in general deals with several hundredths of a gramme, and weighs to one ten-thousandth of a gramme. This work is more often, but less precisely, referred to as semi-micro chemistry.

Then, below the milligram region we have a field as yet not greatly developed, but one which promises to be very important. This, the sub-micro, or microgram field, may refer to any amounts less than those which come under milligram work, and, while usually dealing with several micrograms, frequently translates chemistry into unbelievably minute terms.

It is worth expressing these divisions in more everyday figures. If one takes an ordinary pin and files the head flat, it is possible to place on the level surface about one milligram of ordinary fine table salt, an amount which would be reasonable for the milligram chemist, but on the small side for the semi-micro worker. If this is dissolved in water, and the solution divided into a hundred parts, the sub-micro chemist will probably be content with one of them.

The Early Days of Microchemistry

Although it was stated earlier that microchemistry has been developed during the past twenty years, it must not be assumed that before 1920 microchemistry had not been in existence. As a matter of fact, one must go as far back as the 1840's to reach the earliest work which can be correctly classed as microchemical. At that time a French scientist, Raspail, was investigating the nature of starches, and his work involved the application of chemical tests. Since he was already employing the microscope, he proceeded to alter the classical methods of carrying out the chemical tests, so that he could separate his specimens under the microscope into minute portions, applying different tests in turn to these portions. The results of his tests were then observed through the microscope, and recorded. Since this is, without doubt, chemistry on a small scale, Raspail must be credited with being in all likelihood the first microchemist.

Other chemists adopted these methods, and applied them more widely, particularly in the sphere of the chemical analysis of minerals, since the microscope already found a use in the examination of these materials. Thus, by 1900, at least four text-books had been written which were concerned wholly or in large part with the use of the microscope as an instrumental aid to the chemist. The amounts of material involved, since they were observed under the microscope, were extremely small. And the investigators had in addition developed methods in such a way that, as well as simple addition of chemical reagents, heating, fusion, evaporation and other ordinary chemical operations were possible on this small scale.

The next step of importance in the development of microchemical methods came about 1910. Kuhlmann, an Austrian manufacturer of chemical balances, at that time was turning out special balances of an extremely high precision, according to the standards of the times, which were designed for the chemical analysis of ores. These balances, which weighed only a maximum of two grammes, could weigh with an accuracy of one ten-thousandth of a gramme. Two scientific workers, Emich of Graz and Pregl, first at Innsbruck and then at Graz, had been working for some time on the problem of analysing quantitatively very small amounts of materials, and they persuaded Kuhlmann to improve his balances so that, while still remaining as accurate, they were capable of carrying a load of twenty grammes. At first sight it might appear that this was an unnecessary extension, since only minute amounts of material were to be dealt with. However, it must be remembered that the chemist has not only to weigh his chemicals, but also the vessels containing them. It is not possible to put his materials directly on the balance

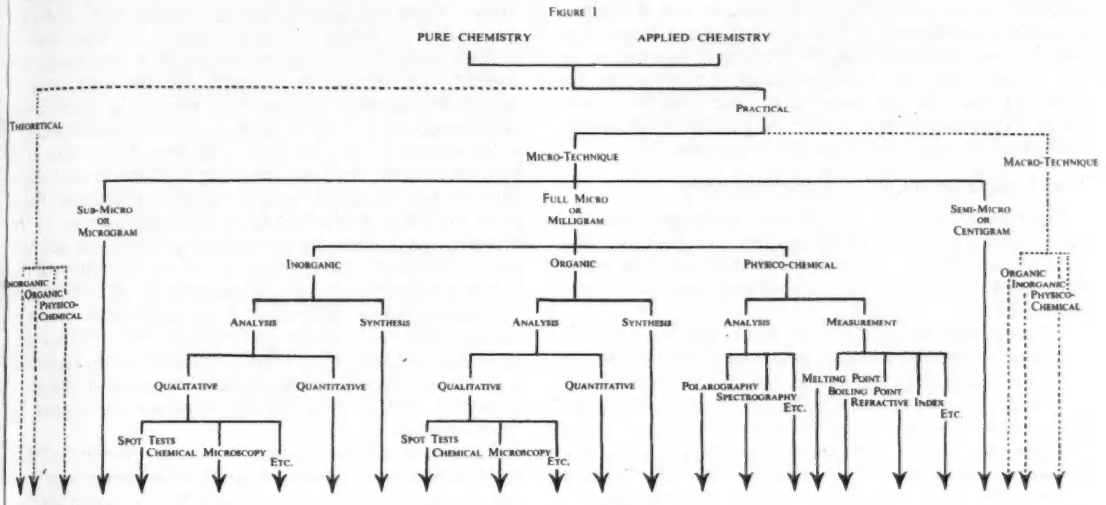


FIGURE 1

pan and weigh them. Since the vessels appropriate to such weighings might be up to ten grammes in weight, this improvement was consequently very necessary. The name of Kuhlman, therefore, as the manufacturer of the first general-purposes microchemical balance, is now an honoured one in the annals of microchemistry.

The two chemists associated with him in this advance, Emich and Pregl, were interested in different branches of chemistry. Emich was primarily concerned with inorganic substances, while Pregl was attempting to apply the improved methods to organic materials, that is, materials originating from living matter such as plants and animals. Modern readers, familiar with vitamins, hormones and other substances of this nature, will be well aware that they occur in extremely minute traces in nature. It is quite possible to start off with several hundredweights of raw material and end up with only a few milligrams of one particular constituent. Now, in order to determine the nature of, say, a plant pigment, it is first necessary to find the amount of each element present in it. Then several other determinations must be carried out to ascertain how these elements are joined together. Only after a considerable amount of evidence of this nature has been accumulated can the chemist work out the structure of the molecule of a substance, and hence arrive at the very desirable knowledge as to how he may set about manufacturing it from simple sources. The older chemical methods required at least several tenths of a gramme of a natural product merely for the determination of the two principal elements in it—carbon and hydrogen. So that the older methods were completely unable to approach the problem of the structure of such naturally occurring products as the vitamins or the flower pigments.

By 1910, Pregl had perfected methods which enabled him to determine the relative amounts of carbon and hydrogen in as little as eight milligrams of an organic substance. By 1912, he had further reduced this amount to two milligrams, which still remains the normal amount for such a determination. At the same time he worked on other processes, so as to be able to carry these out on a correspondingly small scale. It is now possible, with as little as twelve milligrams of a complex substance, to learn a great deal about its nature.

Emich, meanwhile, was reducing the inorganic processes —dealing with metals, salts and so forth—to the micro scale. And the methods which these two workers employed were beginning to spread to other countries, and to be improved on, or supplemented, in other laboratories. The first World War must be held to have delayed the spread of microchemistry to some extent, owing to the barriers hindering the communication of knowledge. But by the nineteen twenties microchemistry had definitely come to say. Chemists from all countries were going to the laboratories of Pregl and Emich to acquire the rudiments of the subject in practice, from the hands of the masters. These chemists, returning, carried on the process of disseminating microchemical knowledge in their own laboratories.

Two other prominent names must be mentioned in connection with the early days. Chamot, in America, was engaged in the collation and extension of the advantages in the use of the microscope in chemistry. He may properly be considered the doyen of what is now known as chemical microscopy. Feigl, of Vienna, became engaged in the development of what we know as spot tests or drop reactions—that is, qualitative chemical analysis carried out with single tiny drops of liquid, and using chemical reactions which, by vivid colour changes, make the results easily visible to the naked eye, so that no magnification by an instrument such as the microscope is necessary. These four men, Emich, Pregl, Chamot and Feigl, then, while they undoubtedly built on foundations which had been laid by earlier workers, may be credited with the major work of the development of microchemistry to the point where it has become a foremost scientific method.

To-day microchemistry is a vital and growing part of

chemistry. Some attempt has been made, in the accompanying "family tree" (Fig. 1), to indicate how it fits into the scheme of chemistry. The portions of the diagram in straight lines represent roughly the region touched on in this article; the numerous branches, which cannot be shown in detail in the diagram, are indicated by arrowheads. The dotted lines represent the parallel development of the other divisions of chemistry as a whole.

The Instruments of Microchemistry

It is now necessary to discuss how investigations on the micro scale have been made possible. Already the two most important instruments in the field of microchemistry have been mentioned, the microscope and the microchemical balance.

With the microscope it is possible to carry out work on amounts of material which it is almost impossible to see with the naked eye. But this is not its only advantage. Very often information can be obtained easily, using the microscope, which would be much more difficult to arrive at using the classical methods of chemistry, even if large amounts were available. If a test is carried out in a test-tube the result may indicate several possible answers. However, use of the microscope may give so much additional information that the possibilities are narrowed down to one definite answer. This means that several extra eliminating tests will have been rendered unnecessary.

This may be explained more fully by use of the (hypothetical) scheme of Table I below.

If the chemist carries out a test with the reagent X on an unknown substance in a test-tube, and obtains a white precipitate, he only knows that he has some of A, B or E. He will then have to carry out tests using reagents Y and Z, so as to decide among these. If, on the other hand, he carries out a test on a single drop of his solution with reagent X, and, on examination under the microscope, finds that he has got cubic crystals, he is immediately aware, without further examination, that he has some of A.

Again, suppose that the chemist wishes to distinguish between two very similar compounds. Such a pair would be those known as sodium dihydrogen phosphate and disodium hydrogen phosphate, which are represented by the chemical formulæ NaH_2PO_4 and Na_2HPO_4 respectively. These substances are so similar that ordinary qualitative chemical tests are useless, for they merely indicate that in both cases sodium and phosphate are present. To distinguish between the two substances it would be necessary, by the older way, to determine the elements quantitatively, since there is twice as much sodium to phosphate in one as there is in the other. This is a long process, in this case requiring perhaps several days. But the two chemicals behave differently towards light, since the atoms are arranged in different fashions in the crystals. And under the microscope it is the work of a few minutes for a practised microscopist to decide which of the two he is examining. Another example of this is illustrated by Fig. 2. Silver chloride and silver bromide are substances with very similar properties. But if they are dissolved in a drop of ammonia and allowed to crystallise, a glance will distinguish the squares and cubes of the silver chloride from the triangular and hexagonal plates given by silver bromide.

Turning now to the balance, it must first be stressed that hand in hand with refinements of this instrument went, not only refinement of the various vessels used in conjunction with it, but also alteration of methods to suit the newer apparatus. The vessels had first of all to be made smaller. Fig. 3 shows diagrammatically a micro-weighing bottle for weighing out powders, while Fig. 4 allows its size to be compared with that of its older forerunner. It will be seen that not only is it different in size, but it also has taken on a new shape. The long "tail" has been added so that it can be handled conveniently with a pair of forceps without being dropped. Feet have been added so that it will sit in an upright position, as otherwise it would be unstable.

The bottle must be handled with forceps only since handling with the fingers would introduce two errors. If one handles a piece of apparatus which is scrupulously clean, it is possible, even if the hands are also absolutely clean, to add as much as several tenths of a milligram to its weight, merely because of the perspiration from the fingers. In addition, the temperature of the vessel will be raised slightly, and on placing it on the balance pan, air currents will be set up, which will alter the apparent weight

TABLE I

Test	*Substance*				
	A	B	C	D	E
Addition of Reagent X gives	White precipitate	White precipitate	Blue precipitate	Green precipitate	White precipitate
Addition of Reagent Y gives	Yellow precipitate	White precipitate	Nil	Nil	White precipitate
Addition of Reagent Z gives	Nil	White precipitate	Nil	Nil	Nil
Precipitate with Reagent X, when examined under the microscope shows	Cubic crystals	Needle crystals	Not crystalline	Plate crystals	Not crystalline

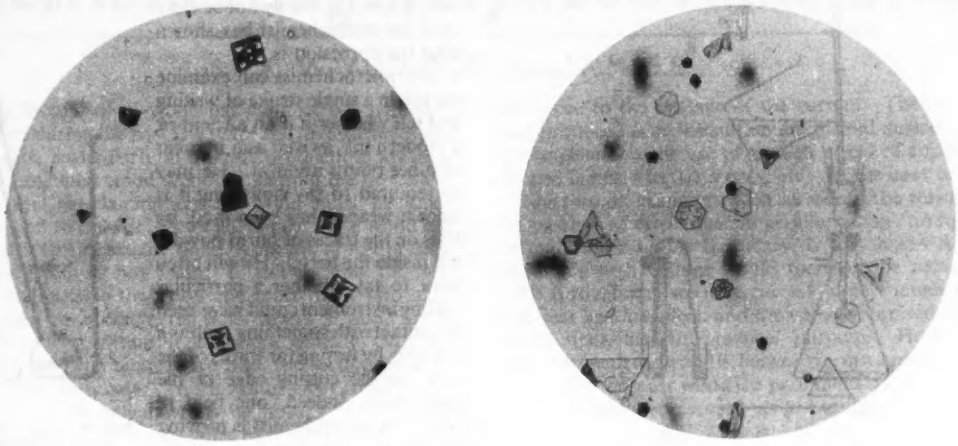
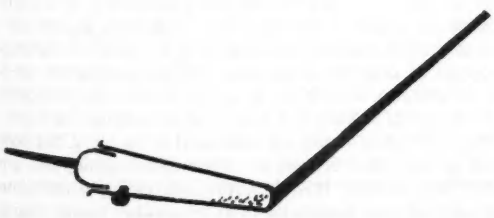


FIG. 2.—Crystals of (*left*) silver chloride and (*right*) silver bromide, magnified 400 diameter.

appreciably. It will be gathered from this that the greatest care will have to be taken to reproduce weighing conditions each time a vessel is weighed. Two instances of the extreme precautions that are necessary will serve to illustrate this. If one places the left hand at one side of a micro-chemical balance, outside the glass case in which it is enclosed, it is essential to place the right hand at a corresponding position on the other side, as otherwise the minute difference in temperature will render a weighing inaccurate. Again, every vessel acquires from the atmosphere a thin film of moisture which is not appreciable to the senses, but which has a noticeable weight in the microchemical sense. If the vessel has been heated it will have lost this film, and will be so much lighter. Special precautions have to be taken to reproduce this film of moisture to exactly the same extent each time before the vessel is re-weighed. In very damp climates it may even be necessary to control the moisture of the air of the whole laboratory in order to achieve this.

Precautions must also be taken against contamination, not only from the fingers, but from dust in the atmosphere, benches, and so forth. In fact, a great part of the attitude of mind which has been discussed earlier consists in aiming at what has been aptly termed "chemical asepsis"—working in conditions of extreme cleanliness which the microchemist would never consider essential for the dishes from which he eats his food!

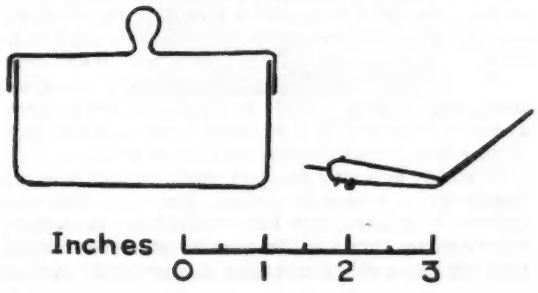
FIG. 3.—Micro weighing bottle, approx. full size.



This survey of the microchemical balance will have shown that the problem of adapting any chemical process to the microchemical scale is not only one of cutting down the size of the apparatus and the amount of material worked with. This will be seen even more clearly if we discuss another specific case. If a chemist has a precipitate which he desires to weigh, he will pass his solution and precipitate through a porous filter which has already been weighed, and, after appropriate treatment and drying, will weigh the filter and precipitate. He will thus determine the weight of the precipitate by difference. Now let us suppose that the total weight of precipitate is one tenth of a gramme, and in the process of transference to the filter a tiny speck—say one tenth of a milligram—is lost by sticking to the wall of the original vessel. The error, then, will be 0·1 per cent. But if the precipitate was a micro one, weighing 2 milligrams, then the working error is really serious, since it is 5 per cent—fifty times as great as in the macro determination. Therefore yet another pitfall that must be avoided is unnecessary transference.

Let us see how this may be overcome in the particular case in point. Fig. 5 is a diagram of the macro apparatus, with, on the same scale, the new micro apparatus, which, it will immediately be seen, is entirely different. In Fig. 6 the apparatus is drawn full size, so that the details can be seen. Instead of the liquid being poured into the filter, a special filter A has been devised, which dips into the

FIG. 4.—Weighing bottles, (*left*) ordinary and (*right*) micro.



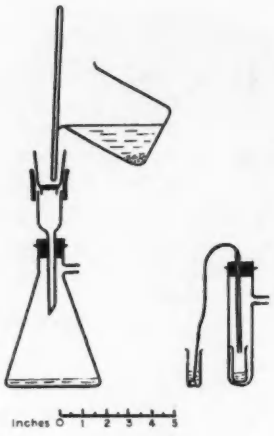


FIG. 5.—Set-up for (*left*) ordinary and (*right*) micro filtration.

liquid, and through which the liquid is sucked off. The precipitation has been carried out in the small beaker B. Once the filter A has been placed in B it is never removed until the end of the determination. Thus none of the precipitate can possibly get out of B. A *and* B have been weighed earlier, and are re-weighted after the liquid has been removed, giving the weight of the precipitate. In effect, the precipitate has never been transferred at all.

While much microchemical apparatus is very simple, and may even, at times, be made on the spot by the chemist from odds and ends of glass tubing, other extensions of microchemical work have been made by the introduction of entirely new methods, which deal with minute quantities, often through very complex instruments. It would be impossible in the space to give these methods, such as spectrography, polarography, colorimetry and electrography, adequate notice. They can therefore only be mentioned by name to indicate that they are very valuable extensions of the means at the disposal of chemists dealing with very small amounts.

How Microchemistry is Used

We now come finally to the applications of microchemistry. The first question which will be asked, and which has only partly been answered in the foregoing is: Why use microchemistry? What are its advantages? Well, it has already been seen that only a small amount may be available, and in that case microchemistry is the only key which will solve the problem. As has been related already, only a minute amount of a natural product may be isolated. One may, perhaps, be presented with a tiny drop of liquid and asked whether it is pure or not. If not, what is it mixed with? Microchemical technique is so refined that a large drop can be split by distillation into as many as seventy fractions, and the temperature at which each of these boils, a characteristic constant, determined.

Or it may be found that tiny specks of corrosion are appearing on a metallic surface. The most important question is, of course, how this corrosion may be stopped. But it is almost certain that the question cannot be answered until the cause of the corrosion is determined. And in turn this will probably not be clear until the microchemist has shown *what* the corrosion is.

The microchemist can examine the ink in a single stroke of writing and tell whether it is an ancient or a modern ink, as well as a number of other points about it. He may be required to say how long it is since a weapon has been fired, by tests on the traces of burnt powder left inside the barrel. He will often have to say whether a particular cutting instrument could have been in contact with something such as a cut wire, by testing for traces of the wire on the cutting edge of the instrument. Indeed, one field in which the microchemist is proving particularly valuable is as an expert witness in legal cases where previously no expert could have hazarded an opinion.

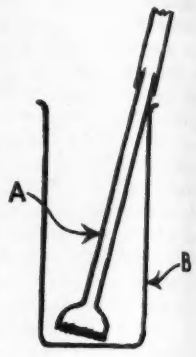


FIG. 6.—Micro filter, approx. full size.

It may be desired to examine the body fluids of a single insect, and determine how these differ chemically from those of other insects of the same species. The microchemist has rendered this possible. Again, it is highly necessary to determine the nature of the minute segregates which occur in steel, and the minute gas bubbles, a mere fraction of a millimetre in diameter, which are to be found in glass. Once again, the microchemist tackles a task which, thirty years ago, would have seemed completely fantastic.

But there is also another side to the picture. Microchemical methods are nowadays being widely used in cases where a mere speck or drop of material is not the only sample. This can largely be traced to the saving in time and the saving in supplementary materials which can be effected. Certain points will be self-evident. Thus, a dealer in precious metals, while being able to supply large samples, will undoubtedly be glad if only small samples are to be destroyed in analysis. But the saving goes much further than this, and may easily be illustrated by a single example. The process of evaporation is one often carried out by the chemist, in order to get rid of unwanted liquid, possibly water. It is quite clear that it will save both time and fuel if only twenty drops have to be evaporated instead of a quarter of a pint. Multiply this saving up by the number of times the operation has to be carried out in one day, and the gain is not only appreciable, but immense.

It is probably fitted to round off this discussion of microchemistry by stressing that the subject is still progressing rapidly. This is most obvious in the sub-micro field, though advances in the other sections are just as many. But it may give some idea of what is to be expected if it is stated that users of sub-micro methods have ascertained that it is quite possible to obtain a positive test on as little as one ten-million-million-million-millionth of a gramme of material dissolved in one thousand-million-million-millionth of a litre of solution. They have been able to take one millionth of a gramme of an alloy and determine with moderate accuracy not only what metals are contained in the alloy, but how much of each alloy is present. The sub-micro methods are still in their infancy. It is, therefore, interesting to speculate just what they will be capable of in yet another twenty years.

Electric Heating in Plywood Manufacture

A. W. ALLWOOD, B.Sc., A.M.I.E.E.

THE manufacture of plywood has assumed an increasing importance during the past few years and many articles and components, particularly in aircraft production, are now made of laminated wood sections. During the process of manufacture, the laminations of wood must be glued together, and to do this it is an advantage if the wood can be heated. This is usually done by means of hot presses, heated by steam or hot water. In this method, the heat is generated outside the wood and must travel into it by conduction. As a result, the outer layers of wood attain the correct temperature much more quickly than the inner, and the time required to heat the section depends entirely on its thickness. This is not of great consequence when thin sheets only have to be heated, but becomes important when thicker sections have to be dealt with, since there will be a time-lag before the heat reaches the centre and there is the possibility of the outer layers becoming damaged. In fact, since wood is a very poor conductor of heat, there is a limit to the thickness of laminated wood which can be manufactured using the steam press. It would therefore be a great advantage if the required heat could be generated uniformly throughout the entire mass of the wood.

A recent development in which high-frequency electric power is used achieves this object. The operation is relatively simple and basically it is only necessary to use a generator of high-frequency power connected to suitable electrodes placed on either side of the wood to be heated. The arrangement is shown in Fig. 1.

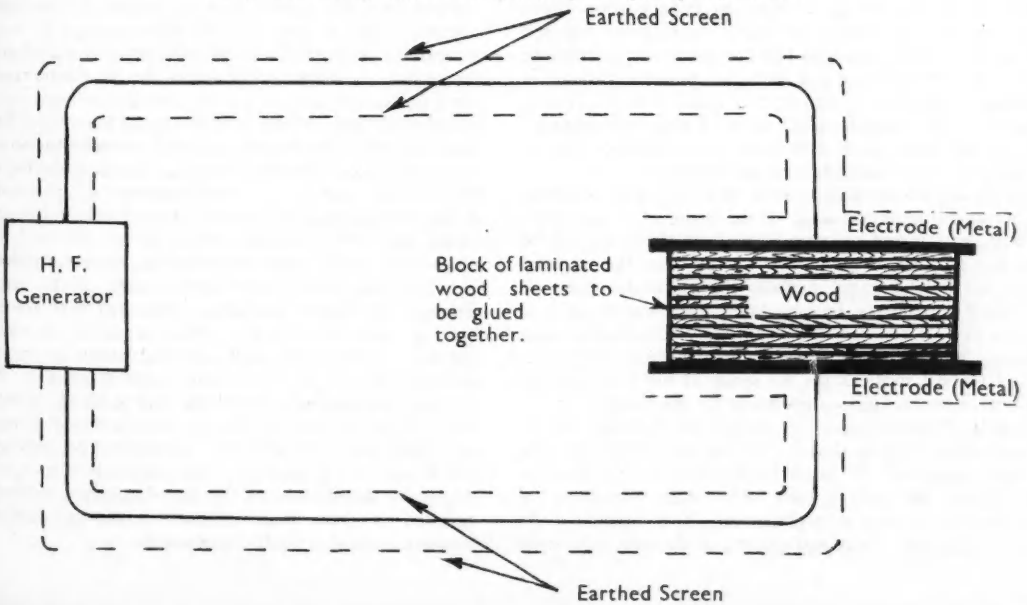
Why High Frequency Power is Used

It is well-known that when a current of electricity is passed through any material, heat is produced due to its resistance to the passage of the current. The amount of heat produced is dependent on the current passed, and this phenomena is made use of in such pieces of apparatus as electric lamps, electric stoves, etc. In the case of poorer conductors or insulators such as wood, the resistance to the passage of direct current or alternating current at the normal power supply frequency, is very high. A correspondingly high voltage would therefore be necessary to force through the wood a current large enough to have sufficient heating effect, and the voltage required would be quite impossible for practical purposes. However, the electrodes with the wood in between form a condenser which is imperfect because wood is a poor dielectric; the arrangement may be represented as a condenser with a high resistance in parallel with it. As the frequency of the supply is increased the current in such a circuit will increase almost in direct proportion, and when the frequency reaches the range commonly known as radio frequencies it is possible to force sufficient current through the wood to heat it as desired. High-frequency current is therefore used for the purely practical reason that it is possible to pass sufficient current to produce the required heat with a reasonably low operating voltage.

Method of Application

In the commercial application of this method of heating wood the frequency used usually lies between 2 and 10 megacycles (2 to 10 million cycles) per second and the voltages used range from 100 volts to about 15,000 volts. The voltage that can be used will be governed to some extent by the thickness of the materials which are to be heated, since it must not be so great as to cause flashover. The amount of power required for a particular application

FIG. 1.—Basic arrangement for heating wood by the high frequency method.



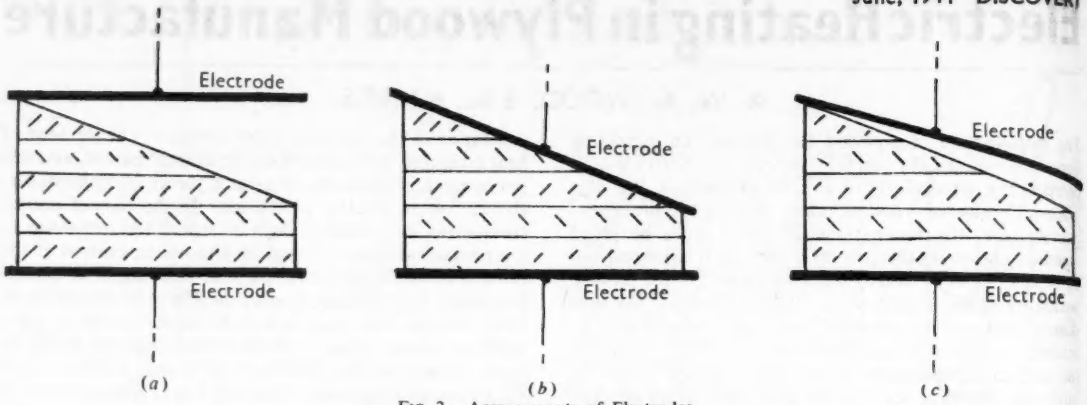


FIG. 2.—Arrangements of Electrodes.

can be calculated from a knowledge of the physical dimensions and power factor of the dielectric. When the dielectric consists of wood, as in this case, the power factor is not a constant but varies with the frequency and moisture content. It can however easily be measured by means of a radio frequency bridge.

Radio frequency generators consist of a valve oscillator fitted with coils for operation on 2, 5 and 10 megacycles and generally have a radio frequency output of 15 to 25 kW. It has been found by experience that frequencies from 5 to 10 megacycles are suitable for most glueing and bonding operations. In order to obtain the maximum efficiency it is necessary to tune the generator to the load. This is done by providing an inductive circuit to match the capacity of the electrodes, and since the frequency is so high, the inductance necessary may be provided by using a loop of copper tube. It is preferable that the generator should be situated near to the load, otherwise it may be necessary to provide a shielded transmission line and a special coupling or matching circuit. Even when these steps are taken the efficiency of the arrangement is unlikely to be more than 50% to 60%, which means that the power input to the generator needs to be about double that required by the load. It is necessary that the generator, connecting lines, and as much of the press as possible should be shielded by means of an earthed metal screen. This is required both for ensuring the safety of personnel and also to prevent interference with radio communications, since the generator is equivalent to a radio transmitter.

The shape and arrangement of the electrodes is a matter of considerable importance. If the material to be heated is homogenous and has parallel surfaces the plates will be flat and parallel to each other. If however the material does not have parallel surfaces the electrodes must be arranged so that the heating takes place evenly. Fig. 2 shows three possible arrangements of electrodes for such a case. Arrangement (a) will cause the thick part of the wood to heat most as the air space at the thin end will present a much higher impedance to the passage of the current. If arrangement (b) is used the thin part of the wood will heat up most as the shorter current path has the lower impedance. In order therefore to ensure that the distribution of heat is even, some such disposition of electrodes as shown in arrangement (c) is necessary. In this arrangement the actual spacing of the electrodes must be adjusted so that each part of the current path has the same impedance, and a calculation of the spacing can be made from a knowledge of the dielectric constant. Another way to get over this difficulty is to use parallel electrodes and to use a spacer made of material similar to that to be heated, to fill the air spaces.

Difficulties and Advantages

The costs of the equipment for using high-frequency power varies according to the output but for a 50 kW. output is of the order of £200 per kW. Operating costs are made up mainly of valve replacements and power costs, and since there are no moving parts other maintenance costs are negligible. It is possible that further development will result in reducing the initial costs but even at present-day figures there are many advantages by which this type of equipment can easily be justified from the point of view of costs.

The chief advantage of the high-frequency method is due to the fact that heat is generated simultaneously and uniformly throughout the entire body of the wood which ensures that the whole block comes up to temperature evenly. It also follows that the time required for a given increase in temperature is independent of the thickness of the wood. A further result is that the total time required for a particular operation is accordingly reduced as compared with other methods of heating, and the thicker the section to be dealt with the more noticeable this factor becomes.

It will be seen from the foregoing that the high-frequency method of heating, for the purpose of plywood or laminated wood manufacture, offers considerable advantages over the methods which have previously been employed. There are as yet, however, several problems to be overcome before wider use is made of this method. These are technical difficulties connected with the shape and spacing of the electrodes, the effect of moisture present in the wood, and the precautions to be taken against interference with radio communications. Many of these problems are well on the way to being solved, and there is every reason to suppose that further development will overcome them entirely. A number of installations are in use at the present time, particularly in America, where the application of the high-frequency method has resulted in great improvements in the production of laminated wood aircraft components.

Fifth Columnists in the Insect World

HORACE DONISTHORPE, F.Z.S., F.R.E.S.Lond.

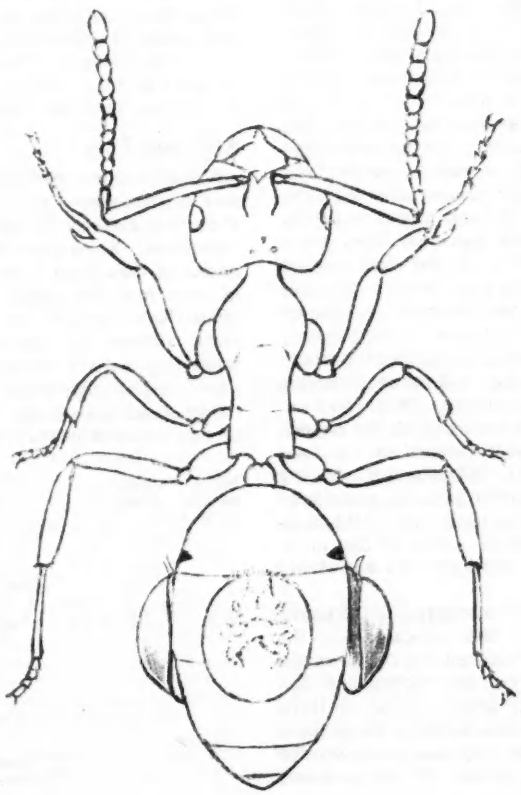
THE origin of the fifth columnist can be traced back to the Spanish Civil War. It may be defined as one who stabs in the back those comrades with whom he lives in apparent amity. The fifth columnist is as well known in the Insect World as in that of *Homo sapiens*; and certainly it has existed there much longer. Take for instance certain mites (belonging to the same family as the cheese-mite, and that delightful little creature the itch) which attach themselves to definite parts of the bodies of their hosts and are found on ants in the Baltic Amber, which dates hundreds of thousands of years before the appearance of man in his earliest form, on this globe.

Ants are particularly susceptible to the insidious penetration of parasites—which is only another name for fifth columnists of all sorts; for they are passionately devoted to the nursing and upbringing of their brood. This makes them more ready to adopt or passively accept such pests and renders it more easy for the latter to exploit them, forcing their company on them, and sometimes actually preying on them for a variety of reasons.

Furthermore, from the enormous numbers of ants, their gregarious habits, wide distribution, overlapping generations and very variable habitats they offer the most favourable conditions for the development of the Fifth Columnist.

As first examples let us turn to those mites which may be found to-day resting on the bodies of living ants. A mite, like a spider, possesses eight legs, and is therefore not an insect which only has six. Nevertheless some young mites only have six legs, which probably points to a common descent. These little columnists sometimes occur in thousands in an ants' nest, the inhabitants of which look as if they were incrusted with salt. They do not eat their hosts as they feed on dead insects which occur in the ants' "kitchen middens"; but the ants become lethargic, their bodies being rendered useless by the numbers of these pests, and they gradually die off. People who have kept artificial colonies of the "Honey-ant" from the "Garden of the Gods" in Colorado have found that on occasions they have been destroyed by the presence of vast numbers of these creatures. I have also observed these immature forms in England on "Wood-ants" in my observation nests; though not in large quantities. Sometimes when a worker-ant which had apparently been quite drowned in the water-trough, when placed under the microscope, the little mites on the limbs of the ant, commenced to revive as soon as the latter began to show signs of animation, and ran up and down their antennæ, etc.

FIG. 1.—Mites attached to the hind part of an ant's body.



Rough Riders of the Ant World

There is a very active and amusing little fellow called "the rider", because it rides on its hosts, resting on the heads, or hind bodies of its porters. Every now and then one of these mites will jump off an ant and spring on to another whilst in motion, with great agility, after the manner of a circus rider. The ants do not seem to mind, or, indeed, to pay any attention to these mites. The object of these manœuvres is, however, to force the ant in question to carry the rider to some suitable situation and the like. Another very small but artful little creature rests on and among the egg-masses of many species of ants. If a packet of eggs be taken from a nest of "wood ants", and carefully examined, a number of tiny little yellow specks may be seen dodging rapidly about on, and between, the ants' eggs. These little mites do not actually harm the eggs, but they feed upon the secretions from the ants' salivary glands with which the eggs are anointed when the ants lick them, and which are necessary for their growth and welfare. When the ants carry about these egg-clusters the mites are, of course, also transported with them. Later in the year when the ants' eggs have hatched, this mite may be found on the bodies of the queen-ants, and also loose in the nests.

Perhaps the most interesting of all the mites which force their company on the unwilling but industrious ant are those called "antennæ bearers". They have been

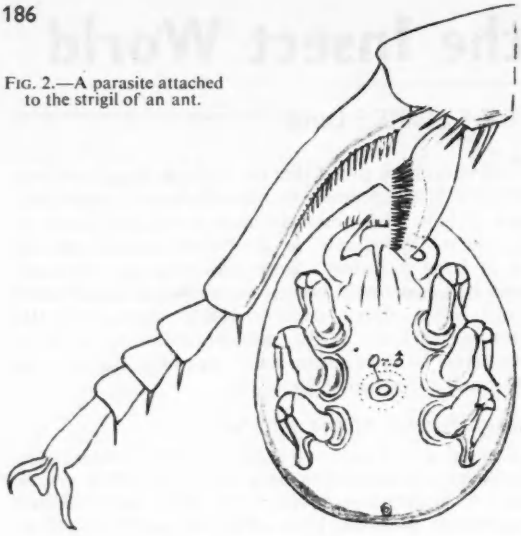


FIG. 2.—A parasite attached to the strigil of an ant.

given this name because they wave about their long front legs, which are directed forwards and look like antennæ. The feet of the three pairs of hind legs are provided with suckers with which they can hold very tightly on to the ant, and are not easily dislodged. Each species lives with a different species of ant and they are all single-hosted. They exhibit most interesting parasitic relations with their hosts, as they are fed by the ants, and are always attached to the ants' bodies. The usual position for these creatures is on the chin of the ant, especially when only a single mite is present on one ant. Sometimes, however, two or more will be found resting on a single ant. The positions taken up are on the chin and forehead, on each side of the head and of the hind-body. They are always arranged symmetrically in order not to upset the ants' centre of gravity when carrying these mites. Six specimens may even, though rarely, be found attached to one ant when they are arranged as follows: One on the chin, one on each side of the head, one on each side of the hind-body, and one on its dorsal-surface. When an "antennæ bearer" resting on the chin of an ant wishes to be fed, it scrapes the mouth of the ant with its antennæ-like legs, and the ant disgorges a drop of fluid which the mite sucks up. These mites are often fed by other ants besides the one on which they happen to be. I have seen a mite solicit another ant for food and the latter immediately feed it. When an ant is feeding and has a mite on its chin, the latter moves to one side of the head to allow its host to feed more easily. When an ant which carries one of the mites is fed by one of its fellows, the "antennæ bearer" leans forward and shares in the meal.

These mites frequently transfer themselves to the young callow ants soon after they have been extricated from the cocoons. The callows often try to get rid of the mites, falling on their backs, rolling on, and rubbing the chin against, the ground, with other antics similar to those of a buck-jumping horse. The mites, however, dodge about on the ants' body out of harms way and eventually the callow becomes reconciled to its fate. It was supposed that those ants which are carrying these mites never leave the nest, and this is no doubt chiefly the case. This is not always so, however, as I once took a pair of a rare species of "antennæ bearer", consisting of a male and female, on the chin and forehead of a worker of the little black "garden-ant", which was promenading on the grass at some distance from its nest. When captured the mites were seen excitedly stroking each other with their long fore legs, stretched across the ant's mouth.

Several other species of mites attach themselves to the bodies of living ants. One of these is a true external parasite, for it causes wounds on the segments of the ant's hind-body, and thus obtains nourishment from the blood of its host. It is round in shape, with a thin rim on the margin, and fits very tightly to the surface of the ant's body. It is very difficult to dislodge; and also obtains free transport as well as sustenance. Two specimens are generally to be found on the same ant, one on each side of the hind body, but a third may also be present on the dorsal surface of the same.

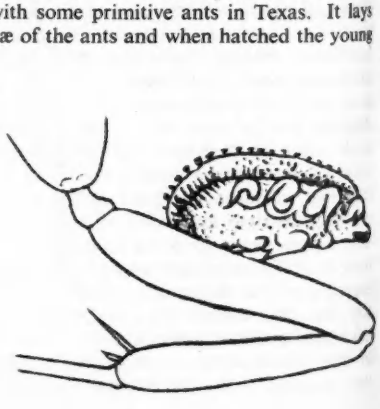
Another curious little fellow possesses more agreeable habits. It grips the pectinate spur on the front feet of an ant with one of its forelegs. The mite obtains food from the substances which its host scrapes off its body and limbs when cleaning itself with these spurs. Only one specimen is usually found on a single ant, but I have occasionally observed two to be present, one being attached to each front spur.

Finally the nearly full grown form of a little mite is always found attached to the thigh of one or all three pairs of legs of a species of yellow ant by means of a string of hardened mucus. This habit reminds us of those of the mites found on ants in the Baltic amber. In this way they obtain protection, food and porterage.

Ants and Flies

Numerous kinds of flies are found with ants, and in the near neighbourhood of ants' nests throughout the world. These associations comprise different degrees of fifth columnism. Some are truly parasitic living in or on the bodies of their hosts; others spend only the earlier part of their lives, sponging in the nests, but not causing actual harm to the ants themselves; others again are artful thieves and daring robbers. There are many interesting cases of curious intercourses between flies and ants. One of these is that of a little fly which lives in its earlier stages with some primitive ants in Texas. It lays its eggs on larvæ of the ants and when hatched the young

FIG. 3.—A mite on the femur of an ant.



fly-grub clings to the neck of the ant-larva by means of a sucker, and encircles its host like a collar. Whenever the ant-larva is fed by the worker ant, the grub uncoils its body and partakes of the feast. At times when there is no food in reach the grub will tweak, with its sharp little jaws, the sensitive hide of a neighbouring ant-larva, or even its own host, till it squirms, and by wriggling incites the worker-ants to bring a fresh supply of food. When the ant-larva spins its cocoon, it encloses that of the fly within its web. The fly changes to a pupa beneath that of its host, which hatches first. The apparently empty cocoon is then thrown on the refuse heap by the ants. The newly-hatched little fly then escapes from the cocoon by the opening made by its host.

There are certain gnats which live in Java, and also others of the same family living in South Nigeria, which are actually fed by species of ants, which hold their tails erect when marching along. These flies frequently stop the ants which are running along on their tracks on tree trunks, and are fed from the mouths of the latter. They thus obtain food from the ants, intended for their own brood. Another daring fly, in South Africa, even robs the fierce "driver-ants" of their brood when on the march. It actually settles and drags the young forms out of the very jaws of the ants.

Some larvæ of flies are ant-eaters as they have evolved the habits of making pits in the sand after the manner of the true "Ant-lions" in which to entrap their prey. These occur in various parts of the world—California, North Africa, Southern Europe and I discovered a species in Sicily. The larvæ of true "Ant-lions" possess very

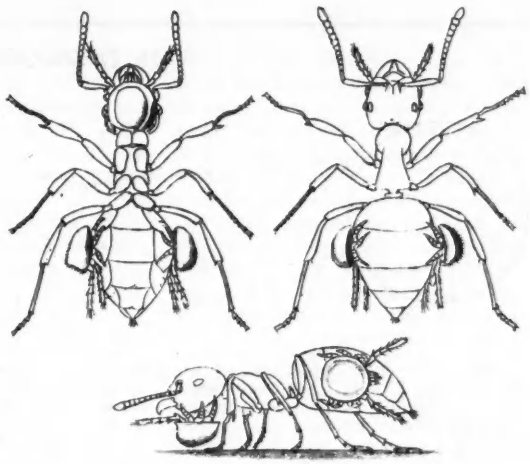


FIG. 4.—Ventral, dorsal and side view of an ant carrying parasites.

formidable jaws with which to seize an ant; but the method of the fly-larva is very different. It captures the fallen insect by swiftly wrapping its body round its victim, after the unfortunate creature has tumbled into the treacherous pit in the sand. These may be considered as symbolical of the pit-falls set by the fifth columnists for the unwary.

PROF. J. B. S. HALDANE, F.R.S.—*continued from p.* 167.

election of Hoover as president of the United States was a world portent more significant perhaps than the Russian large-scale experiment in scientific education "for which Mr. Haldane shows some predilection"—a good instance of how quickly the conventionally "safe" view may come to require reversal.)

Haldane's more recent activities, such as his early campaigning for improved air-raid precautions and his war-time research in connection with submarines, will be familiar to most readers. After his return from Spain, Haldane quickly became one of the most caustic critics of official A.R.P. preparations, though I think he must have found the target something of a sitting rhinoceros.

Haldane's research into physiological problems connected with submarine service dates back to the sinking of the *Thetis*, an event which led to two trades unions, members of which had lost their lives in the disaster, inviting him to attend on their behalf the inquiry into the sinking and to conduct experiments in order to throw some light on the sequence of events that occurred aboard the vessel after she had failed to surface. As a result of those investigations he was asked to make further tests for Admiral M. E. Dunbar-Naismith's Physiological Sub-Committee. He has published certain details about this work, and readers may care to have the reference to his article on the subject—in *Nature*, 1941, **148**, p. 458.

The latest Haldane lecture which I had the opportunity of hearing dealt with this subject and had the title of "Life and Death at High Pressures". I could not help thinking that if one dropped the final "s", that title would fit very neatly on the cover of a full-length biography of the man. I had already decided that, with so much information to hand, it would be easier to write a book than to distil the essence into a thumb-nail sketch!

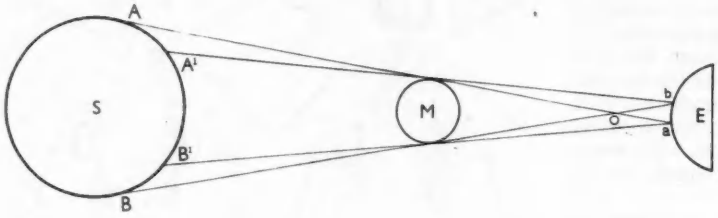
Death to Pediculus

ACCORDING to *Industrial and Engineering Chemistry* a new plant is being rapidly constructed in the U.S.A. at a cost of half a million dollars to augment existing capacity for the production of DDT (dichlorodiphenyltrichloroethane).

This compound was first synthesised in Germany seventy years ago, but its use as an insecticide was only patented five years ago by a Swiss firm. Originally used as a moth repellant, it has now proved an excellent controller of body lice and hence typhus. Its importance in warfare is so great that the first 500-pound batch produced at a pilot plant in America was flown to an overseas battle zone. DDT's potency is said to be so great that a single application dusted on clothing once a month gives protection from disease-carrying vermin.

The Night Sky in July

M. DAVIDSON, D.Sc., F.R.A.S.



The Moon.—Full moon occurs on July 6d. 04h. 27m. U.T., and new moon on July 20d. 05h. 42m. The following conjunctions take place:

July			
18d. 08h.	Saturn in conjunction with the moon,	Saturn	1°N.
22d. 01h.	Mercury ,,	Mercury	0.7 S.
22d. 20h.	Jupiter ,,	Jupiter	2 S.
23d. 11h.	Mars ,,	Mars	2 S.

In addition to these conjunctions the following conjunctions also take place:

July				
5d. 08h.	Mars in conjunction with	Jupiter	Mars	0.2°N.
10d. 04h.	Mars ,,	Regulus	Mars	0.7 N.
20d. 12h.	Jupiter ,,	Regulus	Jupiter	0.5 N.
28d. 08h.	Mercury ,,	Regulus	Mercury	0.0 N.
29d. 17h.	Mercury ,,	Jupiter	Mercury	0.7 S.

The Planets.—Mercury is in superior conjunction on July 1 and is too close to the sun to be favourably observed until later in the month. On July 15 the planet rises at 5h. 20m. and sets at 21h. 02m., and at the end of the month the corresponding times are 6h. 52m. and 20h. 40m. Venus is too close to the sun to be observed easily until late in the month. On July 31 the planet rises at 5h. 15m. and sets at 20h. 17m. Mars, in the constellation of Leo, sets about 2h. after sunset on July 1 and 1h. 10m. after sunset on July 31. At the beginning of the month the planet is 207 million miles from the earth and 222 million miles at the end of the month. Jupiter, in the constellation of Leo, is drawing near the sun and sets at 22h. 26m. on July 1 and 20h. 40m. on July 31, only 50 minutes after sunset. On July 1 the planet is 562 million miles from the earth and on July 31 the distance is 587 million miles. Saturn sets before the sun and is no longer visible.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

July	Sunrise	Sunset
1	3h. 46m.	20h. 21m.
15	4h. 00m.	20h. 12m.
31	4h. 21m.	19h. 50m.
July	**Moonrise**	**Moonset**
1	15h. 01m.	0h. 59m.
15	0h. 38m.	15h. 37m.
31	16h. 16m.	0h. 19m.

The earth reaches aphelion on July 3 when its distance from the sun is about 94,560,000 miles.

An annular eclipse of the sun, invisible at Greenwich, takes place on July 20. At Bombay the magnitude of the eclipse, that is, the area of the sun's surface eclipsed, will be 0.95, at Hong Kong 0.90, and at Madras 0.80. At Adelaide it will be only 0.04.

An explanation of an annular eclipse of the sun is afforded by the diagram in which S, M, and E represent the sun, moon and earth respectively. The lines Aa and Bb are tangents to the sun and moon and meet the earth at the points a and b, so that an observer on the earth between a and b will see a portion of the sun eclipsed. From a and b draw tangents to the moon intersecting the sun at the points B′ and A′. Then all the portion of the sun from A′ to B′ will be invisible to observers between a and b, but observers at a and b will be able to see the portions AA′ and BB′ respectively. An observer midway between a and b would see the visible portion of the sun's disc like a ring of light, and the phenomenon to him would be a central and annular eclipse (from *annulus*, a ring). Notice that the apex O of the cone AOB falls short of the earth, but this would not necessarily occur if the moon were closer to the earth, and in fact the apex O can fall a long way to the right of ab. When this takes place observers between a and b see the phenomenon as a total eclipse. On July 20 the moon is about 247,000 miles from the earth, her mean distance being 239,000 miles, so the circumstances are not favourable for a total eclipse. On January 25, when a total eclipse took place, the moon was only 223,000 miles from the earth, and this small distance provided favourable conditions for a total eclipse.

JUNIOR SCIENCE

How Heat Travels

Some time ago I told you that the heat from a fire comes to you as infra-red radiation. That is one way in which heat can travel from one place to another. Radiation is very important, for it is by radiation that the earth receives all heat from the sun. But there are other means by which heat can be transmitted, for instance by conduction. If you put a metal spoon into a cup of hot tea the handle of the spoon will get hot after some time although it is not in direct contact with the hot water. The heat from the water has travelled along the spoon to the handle by conduction. If you try the experiment with a wooden spoon or with one made of horn or plastic you will notice no appreciable heating of the handle. That means that

Fig. 1

horn, wood and plastic are bad conductors of heat while metals are good heat conductors.

You may have noticed that different objects in the same room seem to have different temperatures. Metal objects appear to be cold while things made of wood or cloth seem to be much warmer. In fact, however, all these objects—if they have been in the room for some time—have all the same temperature. It is only that metals conduct the warmth from your hand away while wood or cloth does not. Use of the good heat conduction of metals has been made in many devices; try to enumerate some.

The fact that metals are good conductors of heat can be demonstrated by a very pretty experiment. If you wrap a single layer of paper tightly around a copper or brass tube and place it in a candle flame (Fig. 1) the paper will not burn. The explanation is that the heat is conducted away from the flame so rapidly by the metal tube that there is not sufficient heat to burn the paper.

K.M.

The Bookshelf

The Physics of Music. By Alexander Wood. (Methuen & Co., Ltd., 1944; pp. 255; 21*s.*).

THE field that has to be covered by the physicist interested in music is a wide one. Not only must he embrace the obvious problems of the theory of vibrations and the extremely complex mechanics of musical instruments, he has also to dabble in the anatomy of the ear, in architecture (for designing acoustically sound auditoriums) and in psychology (since his interest in physical phenomena is ultimately only in relation to the subjective effects that they produce). All these fields Dr. Wood describes competently and thoroughly in his book. In such limited space he can clearly do no more than introduce each topic, and it is, perhaps, the greatest virtue of the book that each section of it leaves the reader with the feeling that he has gained some sound basis from which to start learning, but with an even stronger desire to learn more (but one might wish that the means to satisfy this desire had been provided through the medium of a longer and more analytical bibliography).

Music has in the past advanced largely on the basis of the musician's intuitive skill. But this book makes it clear that there are many ways in which the purely æsthetic quality of music could be improved if the musician possessed also a certain knowledge of physics. The growing co-operation of musician and physicist in recent years has probably been based mainly on the more obvious physical problems of the gramophone, radio, talkies and acoustics of buildings. But this co-operation can now produce startling results in many other fields. An understanding of the tremendously complex phenomena he is using would give the musician a new mastery of technique, which might make our music a generation hence as superior to that of to-day as a Beethoven symphony played by the B.B.C. Symphony Orchestra is superior to an African tribal chant. This book (with the exception of a paragraph here and there) can be read with ease by the average musician and should help him to attain the understanding of musical physics that is required. S.L.

B.B.C. Year Book 1944. (B.B.C. London; pp. 128 + illustr.; 2*s* 6*d*.).

THE attainment by the B.B.C. of its year of seniority is well exemplified in the 1944 Year Book. Sir Ernest Barker, in a close-up review of "Twenty-one Years of Broadcasting," expresses what many of us would say in a general appraisal of the impact of the B.B.C.'s programmes upon our national life. His gentle admonition, "a little less smartness and a little less in the way of tricks of technique" is perhaps a generalisation that we would endorse, but taken as a whole the work of the B.B.C. during the past five years in particular is praiseworthy. The current Year Book depicts in words, diagrams and pictures the events of the last year's broadcasting, with the addition of two or three articles dealing with longer periods of its work.

Outstanding at the beginning of the book is a fairly long extract from the speech made by Sir Allan Powell, Chairman of the Board of Governors of the B.B.C., at the British Association Meeting on March 20th of last year to the Section dealing with the Press, Radio and Cinema. It will be recalled by readers who happened to have been present at that meeting that some very plain language was uttered by several distinguished scientists concerning the B.B.C.'s attitude to science broadcasts, and during the following year one or two sporadic attempts have been made to set up some sort of liaison between scientists and the Talks Department. Some success has been achieved in this direction, and with a few exceptions both qualitatively and quantitatively there has been an improvement of Science Talks broadcast on the Home Programmes. In some ways, however, talks on science sent out on the Overseas programmes and entirely lost to listeners in this country, perhaps are even better. In the twelve months since Sir Allan's address over 200 broadcasts in the Home Service and Overseas Services have dealt with science, technology or mechanics.

In an interesting article headed "This is London Calling," Mr. H. Bishop, Chief Engineer of the B.B.C., describes the engineering set-up behind the microphones. Naturally its technical aspect is not a subject for discussion in public at the present time, but it will make a thrilling story at a later date. Scientists and engineers have combined to present to the world a medium of communication that must be harnessed to the task of securing an ordered and peaceful world civilisation.

Space alone forbids a detailed mention here of the other sections of the Year Book covering many of the different fields of B.B.C. activities; but for the purpose of securing a macrocosmic picture of the far-reaching work of the B.B.C., the Year Book for 1944 should be on every reader's bookshelf. P.V.D.

Flight from Conflict. By Laurence Collier. (Watts & Co., London; the Thinker's Library, No. 101; pp. viii + 84; 1944; 2*s*.).

MR. COLLIER attacks certain views about morality which have been recently propounded by Mr. Aldous Huxley and Mr. Gerald Heard, and also in another form by Mr. Walter Lippman. Mr. Huxley's contention about the validity of mystical experience is examined very carefully and impartially, and Mr. Collier has decidedly the advantage in the argument. It is difficult to see how the mystic has powers of knowledge, as distinct from powers of emotion, superior to those of the non-mystic. In addition, there is "no lowest common denominator" of mystical doctrine, the mystic of each religion being convinced of the truth of his own particularly religious dogma. Most readers will agree with Mr. Collier that Mr. Huxley's argument from mysticism is unsupported, because the mystic "experience" is an emotion rather than a perception.

Mr. Lippman's views as set forth in his *A Preface to Morals* are also examined and severely criticised. Mr. Lippman's object is to find a working basis for everyday morality which can command the allegiance of those who are unable to accept a morality based on revelation. His attempt to revise morality to fit in with "the cosmic process"—an expression due to T. H. Huxley—is shown to be based on a fallacy. He expects happiness to be at least the intelligible consequence of virtue for each man, but if man's virtue is devoted to the attempt to secure the satisfaction by others of the ordinary human desires, this happiness is not attainable as he thinks. Mr. Collier's own views of the good citizen correspond largely with those given by his late father, John Collier, in *The Religion of an Artist*, and if we were guided in our moral and social actions by respect and love for human personality, the world would be a pleasanter place than it is now.

The book is well written and will appeal to a wide class of readers. M.D.

Soviet Light on the Colonies. By Leonard Barnes. (A Penguin Special, 9d.).

THIS book is, in both the best and the worst sense, a work of imagination. Mr. Barnes imagines the analysis of our colonial problems as it might take shape in the mind of a citizen of the U.S.S.R. on a tour of British Africa. If the utterly alert and untiring Comrade Korolenko sometimes strikes the reader as both a little too clever and a size too big for his boots ("I suggest that the proper operational definition of 'colonial policy' is *the dominant trends observable in the totality of the relations between your British society and the societies of the colonies*" . . . "You know, John" he said, "I am quite worried about this funny old empire of yours"), that is all to the good. After all, the same thing might be said about Lemuel Gulliver on the strange self-deceptions of the inhabitants of Lilliput. The book is evidently intended to prod the citizens of a race of unconscious and somewhat somnolent empire-builders into the painful activity of reflection, and it will succeed. R.J.W.

Far and Near

Wilbur Wright Memorial Lecture

THE fact that British scientists and engineers have led the world in the development of the gas-turbine for aeronautical purposes was stressed by Sir Roy Fedden, in his Wilbur Wright Memorial Lecture delivered before the Royal Aeronautical Society on May 25. The lecturer, who is one of our foremost aero engine designers, reviewed the progress of aero engine development from the unsuccessful Langley engine of 1908 to the Whittle jet turbine of the present day.

Sir Roy told his audience how after a comparatively bad start in the race to beat the Germans, eventually engineers in this country had taken the lead in design. He stressed the necessity for maintaining this position and made the suggestion that "the most practical way is to provide a large enough team of highly trained, enthusiastic engineers, with ample modern research equipment."

Colonial Agricultural Grant

A grant of £525,000 to enable the Government of Jamaica to meet the cost of extensive agricultural development is the largest individual item in a return of expenditure on colonial development and welfare schemes contained in a command paper presented to Parliament on May 25. The return relates to the year ending March 31 last, and shows a total expenditure of £4,113,927.

Other grants to Jamaica were £240,000 for the Agricultural Credit Fund £150,000 to extend the work of Jamaica Welfare, Ltd., and an interest-free loan of £150,000 for the production of food yeast.

British Guiana received £243,417 for drainage and irrigation schemes, including provision for increased rice production and the rehabilitation of two rice mills, while £212,000 went to Barbados for agricultural development.

Other schemes of development and welfare include drainage and irrigation in Sierra Leone £393,500, part cost of new dredger for Lagos Harbour, Nigeria, £230,000; water supplies in Kenya, £192,500; soil conservation and agricultural development in Kenya, £139,000; water supply department in Gold Coast, £100,000; and an interest free loan of £10,000 for food yeast production in Mauritius.

Metals in the Stars

"METALS in the Stars" was the subject of the 34th Annual May Lecture of the Institute of Metals which was delivered by the Astronomer Royal, on May 17.

The radiations absorbed or given out by the atoms of a given element are determined by the different possible energy levels of the atoms of the element, said Sir Harold Spencer Jones. The ultimate lines are those associated with atomic transitions from or to the unexcited or ground-state and provide the most sensitive test for the presence of any particular element. The spectroscopic tests for the presence of the metals in the stars are generally more sensitive than those for the non-metals, because the ultimate lines for the metals are generally in the accessible region of the spectrum. When the energy supply is sufficiently great, the outermost electron may be entirely removed from the atom; the atom is then said to be ionised and gives a different spectrum from that given by the neutral atom. Successively higher stages of ionisation can be produced by driving off two or more of the outer electrons.

The features of the Sun and stars that can be studied spectroscopically are merely superficial. The elements present in the outer layers of the Sun are essentially the same as those found in the Earth. The relative abundance of the metals in the Sun, in the Earth and in meteorites are generally about the same. There are some striking differences in the case of the non-metals; thus, for instance, the Sun consists predominantly of hydrogen and helium. This leads to some interesting conclusions about the evolution of the atmosphere of the Earth.

The stars show a wide diversity in spectra, but it is possible to arrange the spectra in a continuous linear sequence. The differences in stellar spectra are due primarily to differences in temperature and not to any marked differences in the relative abundance of the various elements. Density, however, has some effect and from the detailed study of the spectra of giant and dwarf stars of the same spectral type it is possible to infer the luminosities and therefore the distances of the stars.

The spectrum of the Sun's corona, which until recently provided one of the unsolved problems of astronomy, has recently been shown to be due to atoms of iron, nickel and calcium in states of very high ionisation. Interstellar space contains an extremely tenuous gas, in which atoms of the metals calcium, sodium, titanium and iron have been detected.

The H and K lines of ionised calcium are very intense in the spectrum of the average star and can be identified in the spectra of distant universes. This makes it possible to determine the line-of-sight velocities of these universes and, through the correlation between distances and line-of-sight velocity, to infer their distances.

A South African Resin

IN an article in "Some Little-known Resins" printed nearly 30 years ago in the *Bulletin* of the Imperial Institute (1915, **13**, 361) an account was given of an investigation of samples of the coagulated latex of *Euphorbia tirucalli* from Natal. The latex was found to contain 14.3% to 15.7% of caoutchouc and 75.8% to 82.1% of resin. The question was re-opened recently. When owing to the rubber shortage, the possibility of producing caoutchouc from *Euphorbia tirucalli* was again examined. In the current number of the Imperial Institute *Bulletin* (**42**, p. 1) an account of the recent investigation will be found. It was hoped that the industrial use of the resin, which forms the major part of the coagulum, might have offset the cost of extracting the rubber, and certain suggestions for its employment are made.

Indian Students in Britain

LAST month in the House of Commons, Mrs. Cazalet Keir asked the Secretary of State for India what steps were being taken to provide for and accommodate the large number of Indians desiring to come to this country for advanced study and training as soon as circumstances permit. Mr. Amery replied that the Government of India had had these questions under active consideration for some time past in consultation with the High Commissioner for India. All possible steps were being taken to make adequate and proper provision.

DISCOVERY understands that few, if any, Indians have come to this country for purposes of higher study since the beginning of the war. The position with regard to Indians is worse than for Chinese, some students having come from China under the auspices of the British Council.

Penicillin

UP to the end of March 1944, about 500 million Oxford units of penicillin had been distributed in Britain for purposes of clinical research. 420 million units were divided between the hospitals in Oxford, London and Edinburgh chosen as the main centres for clinical trial, and smaller supplies have been made available for clinical purposes to fourteen other centres throughout the country. Sixteen further research projects were approved at a recent meeting of the Penicillin Clinical Trials Committee.

Marfanil—Second to Penicillin

IN North Africa the Germans carried among their medical supplies a sulphonamide preparation called marfanil. This compound, chemically 4-amino-methylbenzene sulphonamide, was administered neat or in tablets containing 50% of marfanil and 50% of sulphanilamide. Tests made with captured marfanil were recently described in the *Lancet* by G. A. G. Mitchell, W. S. Rees and C. N. Robinson (May 13, p. 627), who rank the drug as second only to penicillin. "Of the many substances we have tested in the treatment of infected wounds penicillin alone has given better results than marfanil," they comment. "At present for technical reasons it may prove easier to produce marfanil in much larger amounts than penicillin and thus, even although the former is less effective, further investigation of marfanil is indicated. It is possible also that penicillin used in conjunction with marfanil may give better results than when it is mixed with sulphanilamide or sulphathiazole". Marfanil remains active in the presence of pus: Professor A. Fleming, who has investigated it, finds that it is a much weaker bacteriostatic agent than sulphathiazole (against a certain streptococcus) but is not inhibited by *p*-aminobenzoic acid or pus.

A.Sc.W. Conference

THE 27th Annual Council of the Association of Scientific Workers was held at Beaver Hall, London, at Whitsun. 225 delegates attended.

Professor P. M. S. Blackett, in his presidential address, spoke of the need for scientists to start giving attention to the fascinating and exciting problems of reconstruction, adding that once one embarked on policy for post-war science one would be directly and immediately led into politics in its broadest sense. "Good and essential as the development of science is, it must be remembered that no plan will survive intact in an economic crisis. Science alone cannot cure economic ills. If things go wrong plans for development will go wrong, and money for research will dry up."

Outstanding among the many resolutions before the Council was one, proposed by the Executive Committee, dealing with post-war policy.

Main points from this resolution were:

In the years after the war our tasks will be first the restoration of the material and cultural conditions of life and the rebuilding of science itself in those lands which have been shattered by war and by Fascist occupation, and second the development of the resources of the earth to meet the needs of the peoples.

We believe that science can fulfil these tasks. We do not believe that, when the immediate shock of war has receded, the world need be in any material way poorer than it was before; on the contrary, science in the service of the people can create for them wealth and prosperity hitherto unknown.

There has never been enough food. Science must first increase the world production of food so that all men may at the least enjoy diets adequate for health, which must be further guarded by adequate health services. Technical advances in industry must provide agricultural and other machinery, fertilisers, housing, clothing, fuel, transport and many other things necessary for the increase of living standards throughout the world. Especial attention and unselfish assistance will be needed in overcrowded and underdeveloped areas such as India and China, and in colonial territories. Throughout, production and distribution must be controlled in accordance with scientific estimates of man's requirements. This programme can be carried out by the international collaboration of democratic nations working in the spirit of the Atlantic Charter and the Teheran declaration.

The efficiency of scientific work must be increased by democratic organisation, so that workers of all grades share in its planning as well as in its execution. Free international contact and exchange of ideas are vitally necessary.

With these objects in view, we cannot forget how science was perverted and frustrated between the wars as a result of the control of production in many lands by powerful vested interests. The monopolists are already seeking to use science for commercial competition rather than for human advantage in the post-war world.

In seeking the full use of our work for the benefit of the people we must therefore expect to meet powerful opposition. Scientists will not face this opposition alone. We have a powerful ally in the broad progressive movement of humanity, whose objects require both the elimination of monopolist control in the interests of the few, and the fullest use of science and the dissemination of scientific knowledge. Scientists must take their stand with this movement in order to achieve the full utilisation of their work.

In Britain the decisive section of the progressive forces is the organised trade union movement, of which our Association is a part. It is therefore necessary in the coming period to develop and strengthen our links with other unions, with the Trades Union Congress, and with working class and progressive organisations generally; we must develop in the movement an appreciation of the power of science and of its importance for social advancement. In this way we shall ensure that in the building of the new Britain and of the new world scientists will play their essential part in securing the material and cultural well-being of mankind.

Personal Notes

SIR LEWIS FERMOR, formerly director of the Geological Survey of India, has been awarded the P.N. Bose Memorial Medal for 1943 of the Royal Asiatic Society of Bengal, India's oldest scientific society. The award is in recognition of his "conspicuously important researches on the Archaean rocks of India".

SIR HENRY TIZARD, President of Magdalen College, Oxford, is to be the recipient of the Royal Society of Arts Albert Gold Medal. This award crowns a life-long devotion to aeronautical research. A pilot in the last war, Sir Henry was in charge of Research and Development for the R.A.F. at the beginning of the present war. Nearly two years ago he was elected to his present position as President of the Oxford College at which he was an undergraduate.

PROFESSOR C. M. YONGE is leaving the zoology department of Bristol University to become regius professor at Glasgow, filling the vacancy created when PROFESSOR E. HINDLE left to join the Zoological Society of London as its scientific director.

SIR THOMAS HOLLAND will retire from the posts of principal and vice chancellor of Edinburgh University at the end of this session. He will be succeeded by SIR JOHN FRASER.

NEW president of the Chemical Society is Professor W N. Haworth, professor of chemistry in the University of Birmingham.

SUCCESSOR to PROFESSOR RUGGLES GATES as botany professor of King's College, London University, has been appointed. He is PROFESSOR T. A. BENNET-CLARK, who comes from University College, Nottingham. A plant physiologist, he has since 1937 acted as botanical secretary of the Society of Experimental Biology.

FOR his work in developing the jet-propelled plane GROUP CAPTAIN FRANK WHITTLE has been awarded the James Alfred Ewing Medal for 1943 on the joint recommendation of the Royal Society and the Institution of Civil Engineers.

DR. HENRY HOWES has been appointed by the Colonial Secretary to be the first Director of Education for Gibraltar. Before obtaining wide experience in teaching and administration Dr. Howes was a specialist in Geography and Anthropology.

THE following were elected last month as Convocation representatives of the Faculty of Science to the Senate of the University of London: SIR ROBERT WATSON WATT, F.R.S.; SIR ROBERT PICKARD, F.R.S., F.R.I.C. (re-elected); MR. J. STEWART COOK, A.R.I.C.

DR. JOHN KEITH ROBERTS, Sc.D., F.R.S., who died in London on April 26, aged 47, was assistant director of research in colloid science at the University of Cambridge. He was born in Melbourne, Australia, and was educated at Melbourne and Cambridge Universities. After experience as demonstrator in physics at Melbourne, he came to England, and served as assistant in the physics department of the National Physical Laboratory before receiving his Cambridge appointment. He was a Fellow of Christ's College, Cambridge, and was elected F.R.S. in 1942.

THE death was announced last month of PROFESSOR W. M. THORNTON, head of the electrical engineering department of Armstrong College, Newcastle, for 39 years, at the age of 74. He had retired from his post at Armstrong College in 1937. An expert on mine safety, he had invented an electrical gas-detection miners' lamp which was approved by the Mines Department.

Railway Engine Design

A valuable paper in Condensing Locomotives was read at the General Meeting of the Institution of Mechanical Engineers on May 19th. The authors, Dr. G. V. Lomonossoff and Captain G. Lomonossoff, R.E.M.E., discussed modern condensing locomotives of both the reciprocating and turbine types. They emphasised that such locomotives have recently been built in order to attain one of two mutually incompatible objects—either the achievement of a very high efficiency in temperate climates in the construction of locomotives which in hot or arid countries lose no water. The first object is best attained by use of a turbine with high vacuum, whilst the second is most readily achieved with a reciprocating engine having no vacuum at all. The latter, it was pointed out, has an advantage over the diesel locomotive in that any kind of fuel can be used.

Chemical Engineering Course at Liverpool
A COURSE on Chemical Engineering has been arranged by the Committee of the Birmingham and Midlands Section of the Royal Institute of Chemistry and the lectures are being given at the University, Edmund Street, Birmingham, by Mr. E. Woollatt, B.Sc., A.M.I. Chem.E., of the Liverpool Technical College. The course was primarily designed to help members of the Royal Institute of Chemistry who wished to qualify, in industrial chemistry, for the Fellowship of the Royal Institute, but amongst those attending are many others holding responsible positions in industry and elsewhere. It is expected that before the course concludes those attending will be able to inspect factories in the district and see for themselves the apparatus and machinery described by the lecturer.

Institute of Physics
AT the Annual General Meeting of the Institute of Physics held on May 22nd, the following were elected to take office on October 1st, 1944: President, Sir Frank Smith; Vice-Presidents, Prof. J. D. Cockcroft, Mr. T. Smith and Dr. F. C. Toy; Honorary Treasurer, Major C. E. S. Phillips; Honorary Secretary, Prof. J. A. Crowther; Ordinary Members of the Board, Dr. H. Lowery, Prof. N. F. Mott, Prof. E. A. Owen, Dr. C. Sykes, Mr. R. S. Whipple and Mr. C. S. Wright.

The Annual Report of the Institute, which has just been issued, again reflects the important contributions in the national effort which are being made by British physicists, and records plans which are now being made so that this young profession can continue its vital service for the development of our Industries when hostilities cease. In particular, the Board of the Institute has given consideration to the position of physicists and those desiring to enter the profession during the demobilisation period. It is in touch with the Government on these matters, and through the Joint Council of Professional Scientists, is co-operating with qualified Scientists practising in other branches of Science such as Chemistry, Biology and Geology.

The Institute's Report on the Education and Training of Physicists, which was one of the first of its kind to be issued, was very well received, both at home and overseas (see DISCOVERY, Vol. IV, p. 225). Active steps have already been taken to follow up the recommendations contained in it. Thus the Report making recommendations for changes in the method of teaching mathematics to prospective physicists, which has been prepared by a Joint Committee of the Institute and the Mathematical Association after a lengthy study of the problems involved, is about to be issued, and the enquiry into "the possibility of including the various branches of technical physics within the framework of National Certificates and Diplomas" has made good progress.

The Report records the many technical meetings held by the local branches at home and overseas, and by the subject Groups.

D.S.I.R. in Scotland?
THE establishment of a Scottish branch of the Department of Scientific and Industrial Research is advocated by the Scottish Reconstruction Committee, of which Mr. J. R. Leslie, M.P., is president. The Scottish branch, it is argued, should co-ordinate development of new projects from survey to production and carry out experimental work for which existing organisations are not equipped.

Barley from Tutankhamen's Tomb
QUITE a common form of fraud before the war was the sale of viable seeds which it was claimed had been taken from the tombs of Egyptian tombs. The seeds were usually of cereals or of peas. Recently three scientists examined barley actually taken from the tomb of Tutankhamen, and they have described their findings in *Nature* (1944, **153**, p. 288). The barley was found to be extensively carbonised though its structure appeared to be little damaged, the germ with its scutellum and embryo constituents being intact. It had, however, apparently lost considerably in weight; its density was only about two-thirds that of fresh English barley. What was somewhat surprising was the presence of vitamins in the scutellum; vitamin B_1 was missing, but there was 0.85 μgm. of riboflavin and 28 μgm. of nicotinic acid per gm. The explanation is put forward that the riboflavin survived because of the low relative humidity of the tomb and/or the presence of an oxygen-free atmosphere created by the respiration of the barley, and oxygen absorption by other products stored with it.

Research in Applied Psychology
THE Medical Research Council, by arrangement with Cambridge University, has established a unit for research in applied psychology at Cambridge. The unit works in the University Psychological Laboratory, and is directed by Dr. K. J. W. Craik. The members of the unit will undertake work elsewhere than at Cambridge when required, including investigations within the field of the M.R.C.'s Industrial Health Research Board.

Science in India
PROFESSOR A. V. HILL who recently visited India at the invitation of the India Office has addressed a meeting of the Medical Parliamentary Group of M.P.'s and told them of the conditions in that sub-continent, describing the projected improvement of medical and ancillary services there. It is anticipated that the Messel Lecture which Professor Hill will deliver to the annual meeting of the Society of Chemical Industry will be devoted to the subject of scientific organisation inside India.

The F.B.I. and Research
THE Federation of British Industries is making its industrial research committee, which sponsored the report on research recently published by this organisation, a permanent committee. The terms of reference of this committee are as follows: encouraging industrialists to devote a more adequate part of their resources to the promotion of research and its application to existing products and to the development of new products; providing money for the creation and maintenance of adequate facilities for post-graduate research; encouraging the education of the necessary research and development staff of universities, technical colleges and industrial establishments; promoting contact and collaboration wherever possible between centres of industrial research or institutions and research workers; facilitating co-operative research within British industry, with special reference to the needs of small-scale industries.

The Smithsonian Institution in War-time
ACCORDING to the Annual Report for 1943 of the Secretary of the Smithsonian Institution of Washington, 33 members of the staff have joined the armed forces and five have left to serve in special capacities in various war agencies. Of those who remain, a number give their whole time to war projects assigned them, while all are at call as their special knowledge may be in demand. In spite of such handicaps a great deal of valuable work has been accomplished.

Among additional activities is a series of publications "War Background Studies." Sixteen of these have now been issued, ranging in subject from the origin of Far Eastern Civilisations, the Japanese, the natural history background of camouflage, and poisonous reptiles to the discussion of such broad questions as "the evolution of nations" and "are wars inevitable?" All but the most vital research work and explorations have been suspended with one exception—those activities related to a closer co-operation with the other American republics. Among a number of interesting and valuable accessions to the collections is one specimen of especial note. This is a midget's skull, of which the capacity is 485 c.c., the smallest human skull this far reported. It is of interest to point out that its cubic capacity is not only roughly one-third of the normal adult human, but it is also less than that of the average chimpanzee.

Engineers and Physicists Conference
THE Institution of Chemical Engineers and the Institute of Physics announce a Joint Conference on "Instruments for the Automatic Controlling and Recording of Chemical and Other Processes". Provisional arrangements have been made for the Conference to take place in London on Friday afternoon, September 22nd and Saturday morning, September 23rd. The purpose of the Conference is to promote the interchange of knowledge and experience between those employing automatic controllers and recorders in different fields and to encourage collaboration between physicists and chemical engineers.

The Conference will be open to all interested without charge, whether members of the organising bodies or not.

Further particulars will be sent, on request to the Organising Secretary, Joint Conference, c/o The Institution of Chemical Engineers, 56 Victoria Street, London, S.W.1.

Printed and published by Jarrold & Sons, Ltd., The Empire Press, Norwich.

EDUCATION
HANDBOOK

CONTENTS

PERSONALITIES AND POWERS, *by* E. W. WOODHEAD, M.A., *Director of Education, Norwich.*

EDUCATION AND RECONSTRUCTION, *by* DR. F. H. SPENCER, *Former Chief Inspector of Schools, London County Council.*

THE MODERN IDEA OF A UNIVERSITY, *by* W. G. S. ADAMS, C.H., D.C.L., LL.D., *Warden of All Souls College, Oxford.*

I GIVE YOU—THE THREE R's, *by* MISS M. M. NEWTON *Headmistress, Whitwood Mere Nursery Infant School, Castleford.*

THE JUNIOR SCHOOL, *by* CATHERINE FLETCHER, B.A., *Principal, Bingley Training College.*

THE NON-SELECTIVE SECONDARY SCHOOL, *by* S. R. GIBSON, M.A., *Headmaster, Bec School, London.*

ABILITY AND OPPORTUNITY IN EDUCATION, *by* DAVID JORDAN, M.A. (LOND.), B.SC.(*ECON.*)

RURAL EDUCATION, *by* H. M. SPINK, M.C., M.A., B.Sc., *Director of Education, Northumberland.*

THE DAY CONTINUATION SCHOOL, OR THE YOUNG PEOPLE'S COLLEGE, *by* E. G. SAVAGE, C.B., *Education Officer, London County Council.*

MODERN TENDENCIES IN TECHNICAL EDUCATION, *by* H. LOWERY, M.Ed., Ph.D., D.Sc., F.Inst.P., *Principal, South-west Essex Technical College.*

ADULT EDUCATION, *by* H. MORRIS, C.B.E., M.A., *Secretary for Education, Cambridgeshire.*

THE TRAINING OF TEACHERS, *by* M. V. C. JEFFREYS, M.A., *Professor of Education, University of Durham*

CHANGES IN SCHOOL ARCHITECTURE, *by* C. G. STILLMAN, F.R.I.B.A., *County Architect for West Sussex.*

EDUCATION BLUEPRINTS, 1943. A Summary of Main Suggestions.

"An outstanding book" TIMES ED. SUP. **5/-** *"A most useful book"* SCHOOLMASTER

Postage 6d.

Jarrold & Sons, Ltd., St. James, Norwich.

DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

Published each month at 1/6

The Annual Subscription is 19/- post free

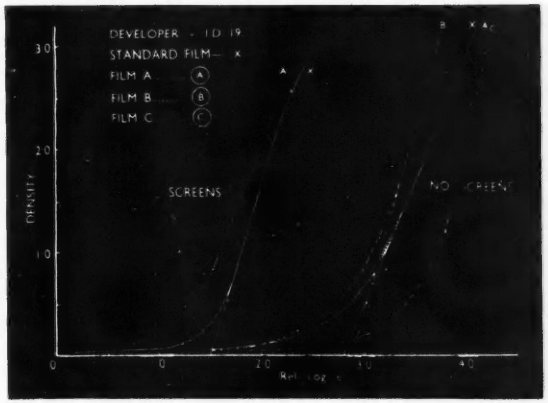
EDITORIAL AND ADVERTISEMENT OFFICES

THE EMPIRE PRESS, NORWICH

Phone 21441

ILFORD PRODUCTS

FOR INDUSTRIAL RADIOGRAPHY



THE need of Industrial Radiography to-day is for a range of sensitised materials varying in their characteristics according to the work to be done. Ilford Limited have met this need with 3 distinct types of X-ray films which fully cover every requirement. A description of these films is given below.

The diagram above shows the characteristic curves of these films in comparison with Ilford Standard X-ray film used in medical radiography.

ILFORD Industrial X-ray Film A

An exceptionally fast screen film which can also be used without screens or with metal screens—a truly "general purpose" film, suitable for the radiography of all structures from the lightest to the heaviest whether with X-rays or Gamma rays

ILFORD Industrial X-ray Film B

A fast non-screen film, insensitive to the fluorescence of salt screens, but usable with metal screens—an improvement on the general purpose film A for all exposures which either must be made without salt screens for the sake of definition, or which can economically, and for preference be made without salt screens.

ILFORD Industrial X-ray Film C

A slow, fine grain, high contrast film for the detection of the finest detail in light structures, or in thin sections of heavier materials, which can be easily penetrated

ILFORD
INDUSTRIAL X-RAY FILMS

The following Ilford booklets contain full information of all Ilford Industrial X-ray materials and will prove useful to Industrial Radiographers

"Ilford Products for Industrial Applications of X-rays and Gamma Rays."

"Photography as an Aid to Scientific Work."

ILFORD LIMITED, ILFORD, LONDON

SORCERY

THE sorcerer was reputed to have the power of converting human beings into strange animals. He turned princesses into frogs — men into swine. As the change was almost always for the worst, his magic powers were greatly feared — and with good reason! The sorcerer of the present day is the organic chemist, but his work is everywhere welcomed, because the changes he makes possible are always for the better. Have you ever seen a piece of cotton cloth coming straight from the loom? A drab and shabby-looking article indeed. But see it later, after it has been cleaned, softened, filled, made creaseless and given a lustre. What a transformation is there . . . sow's ear into silk purse, toad into princess . . . a transformation directly due to the wide range of textile chemicals known as auxiliary products, made by the British dyestuffs industry. There is little that the British organic chemists cannot do with textiles. They have auxiliary products which make cotton as transparent as glass, others which soften it to resemble swansdown or make it so stiff that a pleated collar sticks out like an old-time ruff. They can make cotton look like silk or dull the lustre of rayon. They have chemicals known as stripping agents, which take the dye out of a fabric, and wetting agents, which make materials more absorbent. They have even evolved a product which enables the softest fabric to repel water without loss of texture. It is no exaggeration to say that the chemist through these organic auxiliary products *makes* the modern fabric. It is the chemist who transforms it from a lifeless material into the highly attractive, beautifully finished product you buy in the shops.

ICI

Imperial Chemical Industries Limited, London, S.W.1

he British
They have
as trans-
resemble
pleated
They can
lustre of
stripping
bric, and
ls more
product
el water
geration
organic
bric. It
a lifeless
autifully
shops.

.W.1